KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

TASK 250 REPORT

SOUTH SAMMAMISH BASIN REFINING WASTEWATER SERVICE ALTERNATIVES

October 2003

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INTRODUCTION

The South Sammamish Subregional Planning Area, referred to here as the South Sammamish Basin, is one of King County's fastest growing wastewater service areas. Many of the wastewater conveyance facilities within the basin lack sufficient capacity to convey peak flows over the next 20 to 50 years. The Conveyance System Improvement (CSI) Project was intended to study service areas with capacity problems and to make recommendations for long-term upgrades and improvements to bring conveyance capacity in line with projected flows.

Task 210 of the CSI project for the South Sammamish Basin reviewed basin planning history and population and employment forecasts. Task 220 inventoried existing conveyance facilities that serve the basin, and Task 230 reviewed the natural environment within the basin to identify limitations and constraints that would impact the planning and construction of needed improvements. In Task 240, the CSI project team made flow projections for the basin, identified hydraulic bottlenecks, and developed a list of changes or improvements that would help alleviate the basin's capacity problems. Eleven partial solutions (identified as Alternatives A through K) were developed, and two packages, each a combination of several of the eleven partial solutions, were assembled and analyzed. The two packages were then presented to King County at a February 2002 Decision Workshop for selection of a preferred package of improvements or "Working Alternative." The Working Alternative was then be refined to a point where it could serve as a starting point for preliminary design of needed upgrades and improvements.

This CSI Task 250 report summarizes the Decision Workshop, further delineates and refines the elements of the Working Alternative, and addresses issues raised at the workshop. Following this refinement, cost estimates were revised, and a preliminary implementation strategy was developed. This Task 250 report provides a more complete description of the Working Alternative for the County's Capital Improvement Program group, and it serves as a roadmap for the project predesign team.

The report is arranged as follows:

- Part 1: Decision Workshop Summary
- Part 2: Refinements to the Working Alternative
- Part 3: Analysis of Issues Raised in the Decision Workshop
- Part 4: Revised Project Cost Estimates
- Part 5: Plan Implementation: A Summary of the Next Steps

This Task 250 report summarizes and builds upon the information developed in the previous tasks (Task 210 through 240). For more detailed background information, the earlier CSI South Sammamish Basin reports should be consulted.

PART 1: DECISION WORKSHOP SUMMARY

At the end of the CSI project team's work on Task 240, the 11 original, partial solutions (designated Alternatives A through K) had been evaluated, and several of the partial solutions had been combined into two alternative packages, each of which would comprehensively address wastewater conveyance capacity problems expected to occur in the South Sammamish Basin through 2050. These two packages are summarized in as follows:

1. Package 1 Components:
   - Diversion of part of the Sammamish Plateau flows to the NE Lake Sammamish Interceptor.
   - Diversion of Issaquah Highlands flow away from Issaquah Creek Interceptor.
   - Peak flow storage in both Issaquah and Sammamish Plateau.
   - I/I reduction in the Issaquah 1 and Issaquah 2 modeling basins.
2. Package 2 Components:
   - Diversion of flow along the I-90 corridor to the Eastside Interceptor.
   - Diversion of Issaquah Highlands away from Issaquah Creek Interceptor.
   - Peak flow storage in both Issaquah and Sammamish Plateau.
   - I/I reduction in the Issaquah 1 and Issaquah 2 modeling basins.

On February 11, 2002, the CSI project team reviewed the two packages with a collection of staff from King County and the Regional Infiltration/Inflow (I/I) program at a Decision Workshop. The purpose of the workshop was to describe the South Sammamish basin conveyance planning effort and to arrive at a consensus on specific conveyance improvements (i.e., a "Working Alternative") to recommend to the King County Capital Improvement Program (CIP) group. The presentation materials from the workshop are included as Appendix A to this report.

The workshop began with a description of the South Sammamish Basin and the existing facilities, a review of flow projections, and identification of capacity shortfalls. After the key issues driving the need for conveyance upgrades were introduced, the CSI project team summarized each of the eleven component alternatives included in the Task 240 report. Finally, the two separate packages were described, and phased project construction costs and operation and maintenance costs for each package were presented.

The group consensus was that Package 1 is the better of the two packages and would constitute the Working Alternative for the South Sammamish Basin. The Working

Alternative combines flow diversions, storage, and I/I control to reduce flow to the system bottlenecks and utilize the capacity of the existing facilities in the basin. Figure 1 is a schematic diagram showing the improvements that make up the Working Alternative.

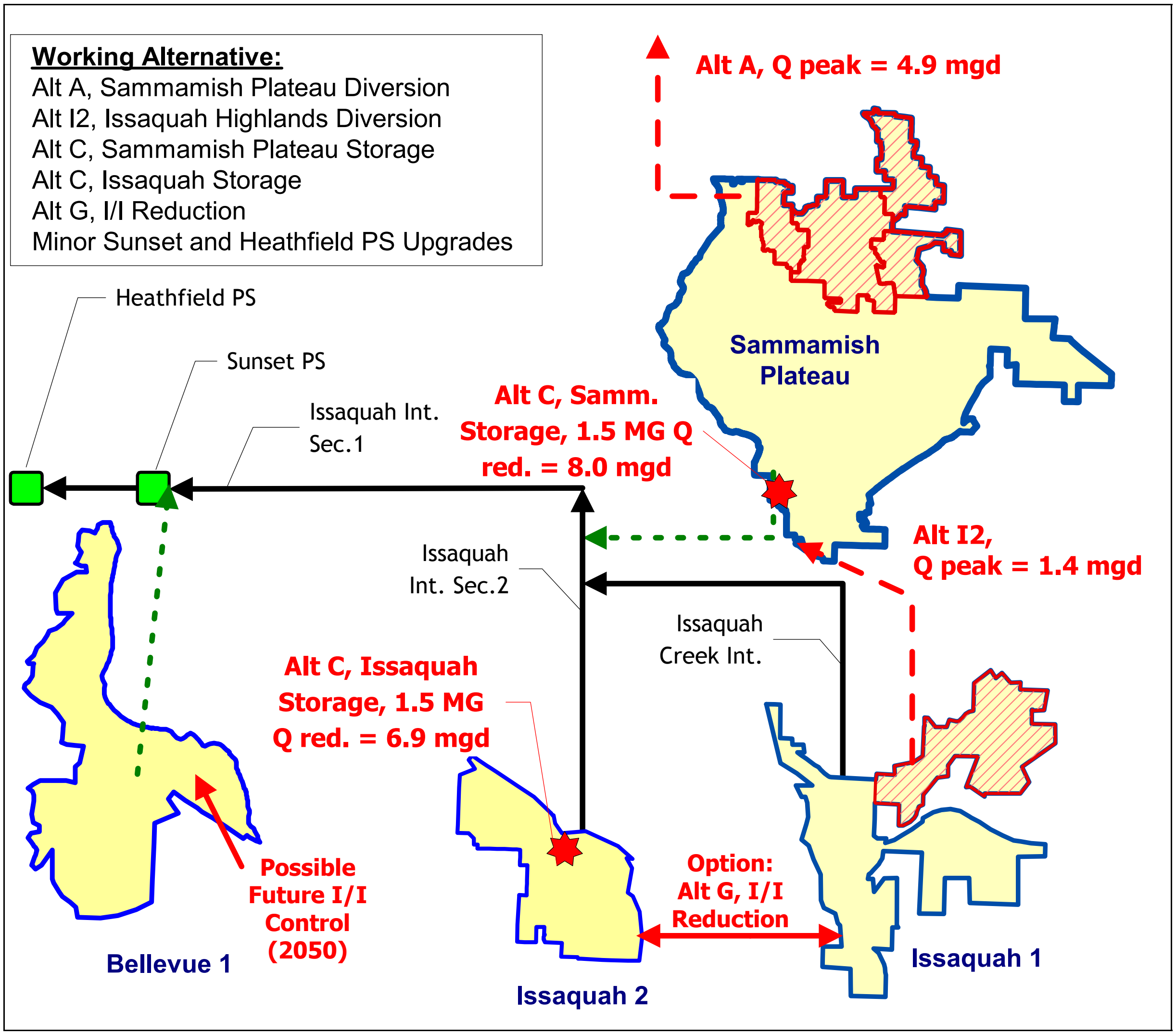


Figure 1. Working Alternative Component Conveyance Upgrades

While the group agreed the CSI project team should proceed with refining the Working Alternative, group members also raised specific issues concerning the Working Alternative and made recommendations for further analysis by the project team. Issues raised included:

1) Given the uncertainty associated with future growth forecasts and I/I projections, how would Package 1 be impacted if the future flows in the basin were higher/lower than forecasted in Task 240?

2) The operation and maintenance assumptions for storage systems and other conveyance facilities should be brought inline with County practices, and the CSI team's assumptions should be based on existing inspection, operation and maintenance cost data provided by the County.

3) Could the sewer that would divert wastewater northward from the Sammamish Plateau be eliminated by constructing more storage facilities in Issaquah and the Sammamish Plateau?

After the Decision Workshop, the CSI project team began gathering more information and refining the Working Alternative. In addition, the CSI project team addressed the specific questions raised in the Decision Workshop.

PART 2: REFINEMENTS TO THE WORKING ALTERNATIVE

The Working Alternative focuses on *reducing* the peak flow in the Issaquah Interceptor Section 1 (lake line) and downstream facilities. The reduction in peak flow is accomplished through a combination of flow diversion, peak flow storage, and I/I control. In addition, the Working Alternative was amended to include minor improvements to the Sunset and Heathfield Pump Stations to increase the maximum pumping capacity to 21 million gallons per day (mgd) at each station.

The Working Alternative meets King County goals in several ways:

1) All pipeline facilities will convey the 20-year storm, and pump stations will convey the 20-year storm with minor station modifications.

2) This is not simply a *large pipe solution*. Diversion and storage alternatives allow phased construction and coordination with ongoing King County projects.

3) Thirty percent of total capital cost could be deferred until 2018 to 2020.

4) The plan requires no new pump stations. Gravity in/out storage facilities and gravity sewers would minimize the additional operation and maintenance effort in the basin.

The Working Alternative would be implemented in a phased approach, so facilities are added or upgraded in time meet the basins' peak 20-year flow but not before hand and so facility sizes can be adjusted as flow projections are updated. Phasing the improvements allows for more capital budget flexibility and also allows King County to assess and incorporate the Regional I/I program results. Tables 1 and 2 summarize the future capacity shortfalls of the existing facilities and the timing of adding capacity or reducing flow by implementing the Working Alternative. Following these tables, Figures 2 and 3 show the results of Tables 1 and 2 graphically for Section 1 of the Issaquah Interceptor and the Sunset and Heathfield Pump Stations. The effective system capacity in Figures 2 and 3 shows the combined impacts of flow reduction and increased capacity (e.g. the minor upgrades to the pump stations).

Table 1. Future Capacity Shortfalls for Existing Facilities[1]

	2010	2020	2030	2040	2050
Required Flow Reduction or Capacity Increase in Each Facility by Decade (mgd):					
Issaquah Creek Interceptor[1]	0.3	1.6	1.8	2.2	2.4
Issaquah Interceptor Section 2	0.0	6.2	8.2	10.2	11.8
Issaquah Interceptor Section 1	0.4	8.9	10.9	12.9	14.5
Sunset and Heathfield PS's	8.2	17.2	19.7	22.1	23.9
Eastgate Trunk	4.4	14.1	16.9	19.8	21.7

Table 2. Flow Reduction or Capacity Increase via the Working Alternative

	2010	2020	2030	2040	2050
Flow Reduction or Capacity Increase via Working Alternative (mgd), including [Year Built]					
Issaquah Highlands Diversion[2] [2010]	0.6	1.1	1.1	1.3	1.4
Sammamish Plateau Diversion [2010]	1.9	3.6	4.4	4.6	4.9
Upgrades to Sunset & Heathfield P.S. [2010]	3.0	3.0	3.0	3.0	3.0
If Necessary: I/I Removal in Bellevue 1 [2050]	–	–	–	–	1.1
Flow Reduction via Storage Without Issaquah I/I Control:					
1.5 MG Storage: Issaquah [2020]	–	6.3	6.5	6.7	6.9
1.5 MG Storage: Sammamish Plateau [2010]	4.4	7.4	7.6	7.8	8.0
OR Flow Reduction via Storage With Issaquah I/I Control:					
1.5 MG Storage: Issaquah [2020]	–	4.3	4.3	4.4	4.4
0.7 MG Storage: Sammamish Plateau [2010]	4.4	7.4	7.6	7.8	8.0
I/I reduction in Issaquah 1[3] [2040]	–	–	–	1.5	1.5
I/I reduction in Issaquah 2[3] [2020]	–	1.0	1.0	1.0	1.0
Flow Reduction/Capacity Increase (mgd)[4]	**9.3[4]/9.3[4]**	**20.3/19.3**	**21.5/20.3**	**22.1/22.3**	**23.9/23.9**
Required Flow Red./Capacity Inc. (mgd)	**8.2**	**17.2**	**19.7**	**22.1**	**23.9**
Existing Facilities Within 20-Year Control?	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes

1. The "required flow reduction" for each conveyance facility was calculated in the Task 240 report by comparing the flow projections by decade with the full-pipe capacity of the sewers and tested pumping capacity of the pump stations. The Working Alternative utilizes capacity in existing facilities by diverting, removing or storing peak storm flows upstream. The "required flow reduction" should be compared with the total flow reduction to determine if the existing facilities will meet the once per 20-year peak flow.

2. Issaquah Creek Interceptor is only affected by the Issaquah Highlands Diversion and the Issaquah 1 modeling basin I/I reduction.

3. Assumes the Issaquah 1 and Issaquah 2 modeling basins' highest 600 acres have 20-year I/I values of 4,000 gpad, which is 30 to 40 percent higher than the basins' average. If these leakiest sections of the basins were reduced to 1,500 gpad, the total removal would be 1.5 mgd in each basin.

4. The total capacity increase/flow reduction is calculated by summing (1) the diversion to NE Lake Sammamish Interceptor flow reduction, (2) Upgrades to Sunset and Heathfield P.S. , (3) Bellevue I/I removal, and (4) either the storage and I/I control flow reductions in Option 1 or Option 2. Note: Issaquah Highlands diversion only affects the flow in the Issaquah Creek Interceptor, because flows are routed into the King County system downstream.

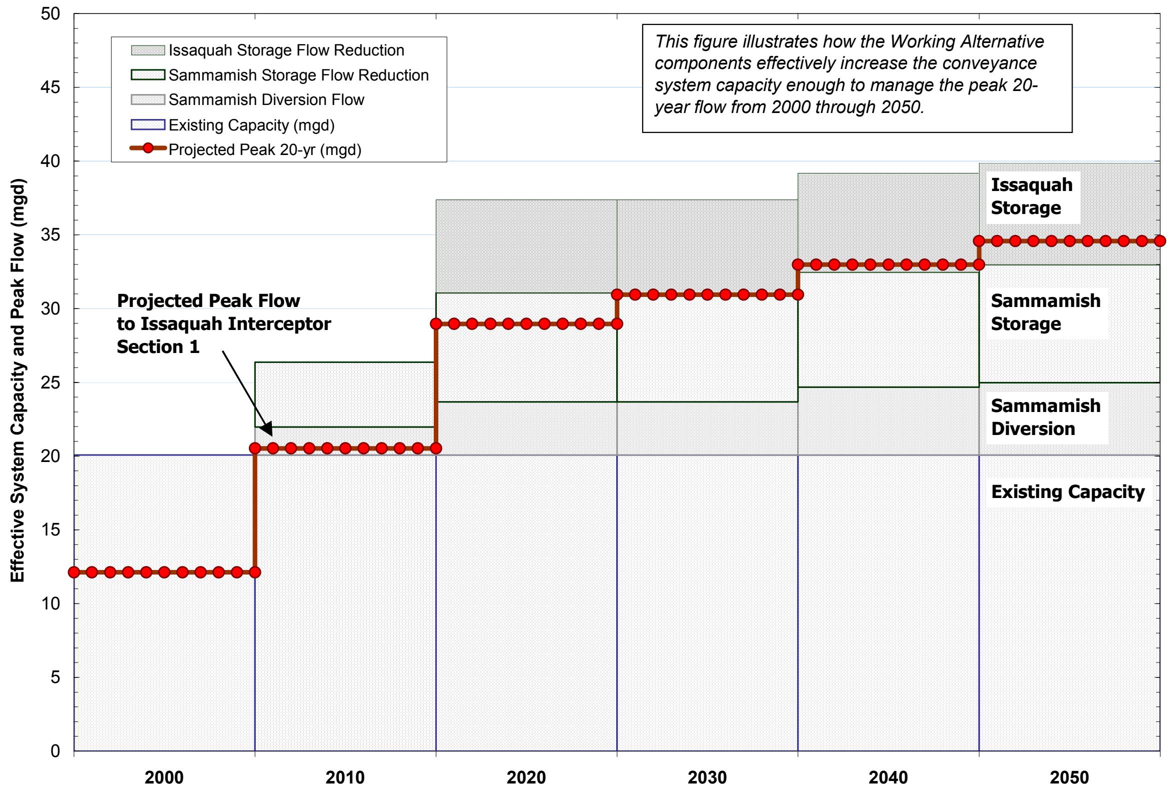


Figure 2. Working Alternative System Capacity: Issaquah Interceptor Section 1

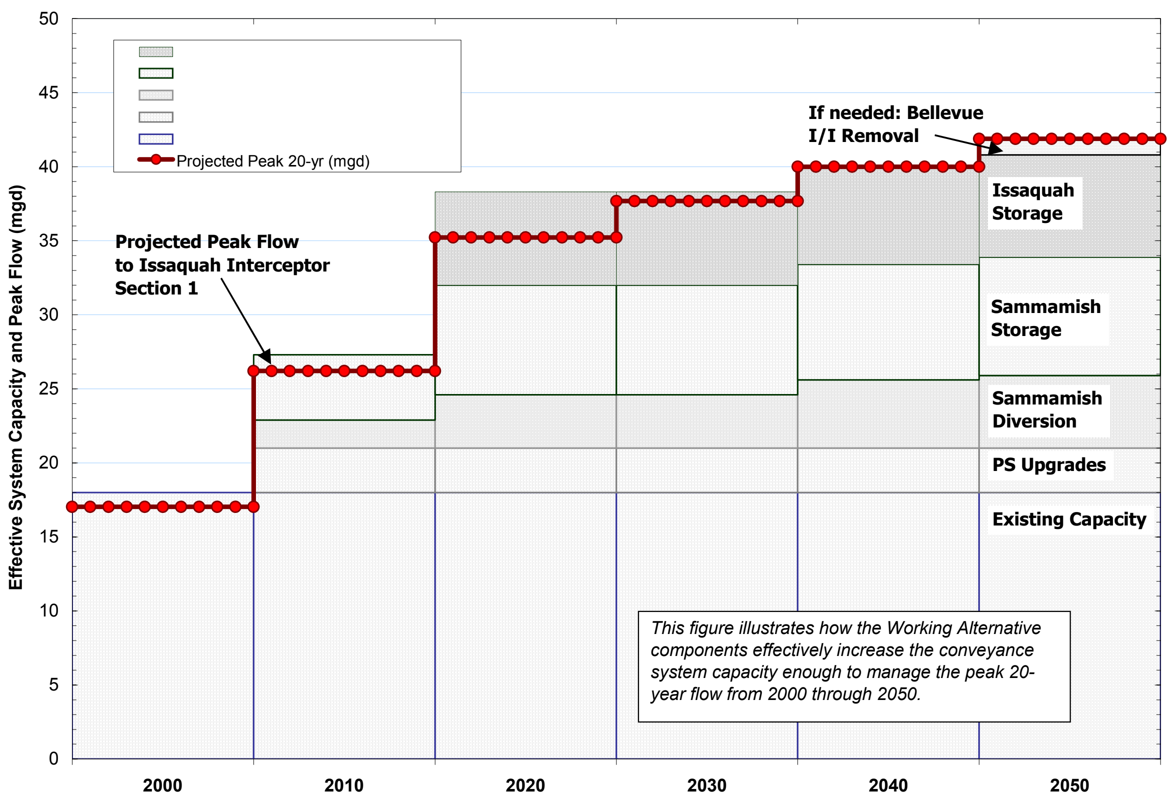


Figure 3. Working Alternative System Capacity: Sunset and Heathfield P.S.

The upgrades listed in Table 1 will bring all of the facilities in the South Sammamish Basin to King County's peak 20-year conveyance standard throughout the planning period, with the possible exception of the Issaquah Creek Interceptor. According to flow projections, diverting the Issaquah Highlands away from the Issaquah Creek Interceptor will provide some relief, but there will be a 0.5 to 1.0 mgd capacity shortfall from 2020 to 2050. King County can eliminate this shortfall while implementing the Working Alternative by (a) diverting more wastewater through the Issaquah Highlands Relief Sewer (Alt I2, refined later in this document), (b) siting some of the Issaquah storage upstream of the Issaquah Creek Interceptor or (c) removing I/I from Issaquah basin 1.

The following sections provide a more detailed analysis each of the components of the Working Alternative. The intention of this part of the report is to review specific aspects of the Working Alternative in sufficient detail that the King County CIP group can initiate predesign projects.

Diversion Northward of Some Sammamish Plateau Flow

Diverting flow from the northern part of the Sammamish Plateau northward to the NE Lake Sammamish Interceptor would reduce demand in Section 1 of the Issaquah Interceptor, which is a major focus of the Working Alternative. There is enough excess capacity in the NE Lake Sammamish Interceptor to accept flow from the northern part of the Sammamish Plateau and still accommodate the forecasted growth in its own drainage area.

Diversion Point for Northward Diversion

The CSI project team considered the need for conveying high flows *and* low flows when refining the route for the diversion from the northern part of the Sammamish Plateau to the NE Lake Sammamish Interceptor. Designing a pipeline to convey near-term, low flow at solids-carrying velocities (i.e., at 2 feet per second (fps)) and future peak flows without surcharge proved challenging because of the wide range of flow and the flat topography near Lake Sammamish. Future flows are projected to range from a 2010 base flow of 0.6 mgd to a 2050 peak 20-year flow of 4.9 mgd.

After examining three different diversion points, the CSI project team recommended a diversion starting at Inglewood Hills Road (see Figure 4). Starting from that point diverts more flow per capital dollar spent than the other two diversion points evaluated, and it does not require a pump station to send flow north.

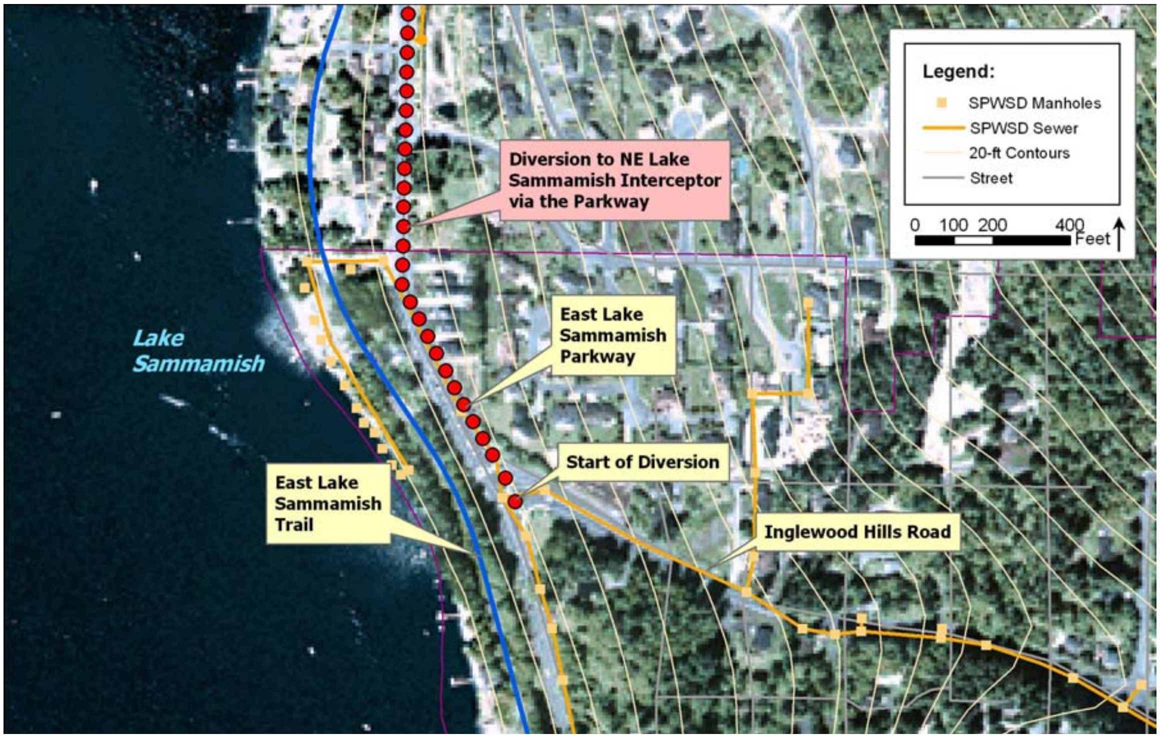


Figure 4. Point of Northward Diversion of Sammamish Plateau WSD Flow

Alternative Pipeline Alignments

When Alternative A was formulated in Task 240, the CSI project team focused on the alignment along East Lake Sammamish Parkway because it was not known if the East Lake Sammamish Trail would be developed and available to the County as an alignment. With the dismissal of a lawsuit that attempted to block construction of the trail, a trail alignment should be examined. This section compares the trail and parkway routes.

Figure 5 shows ground surface profiles of alignments along East Lake Sammamish Parkway and the East Lake Sammamish Trail, both developed with a digital elevation model (DEM) from U.S.G.S. map sources[1].The profiles clearly show the dramatic decrease in elevation as the alignment moves from roadway to the shoreline.

[1] A US Geological Survey DEM with 10 x 10m pixel size was used to develop the ground surface profile. While this is an appropriate method for planning purposes, the design project should include an alignment survey.

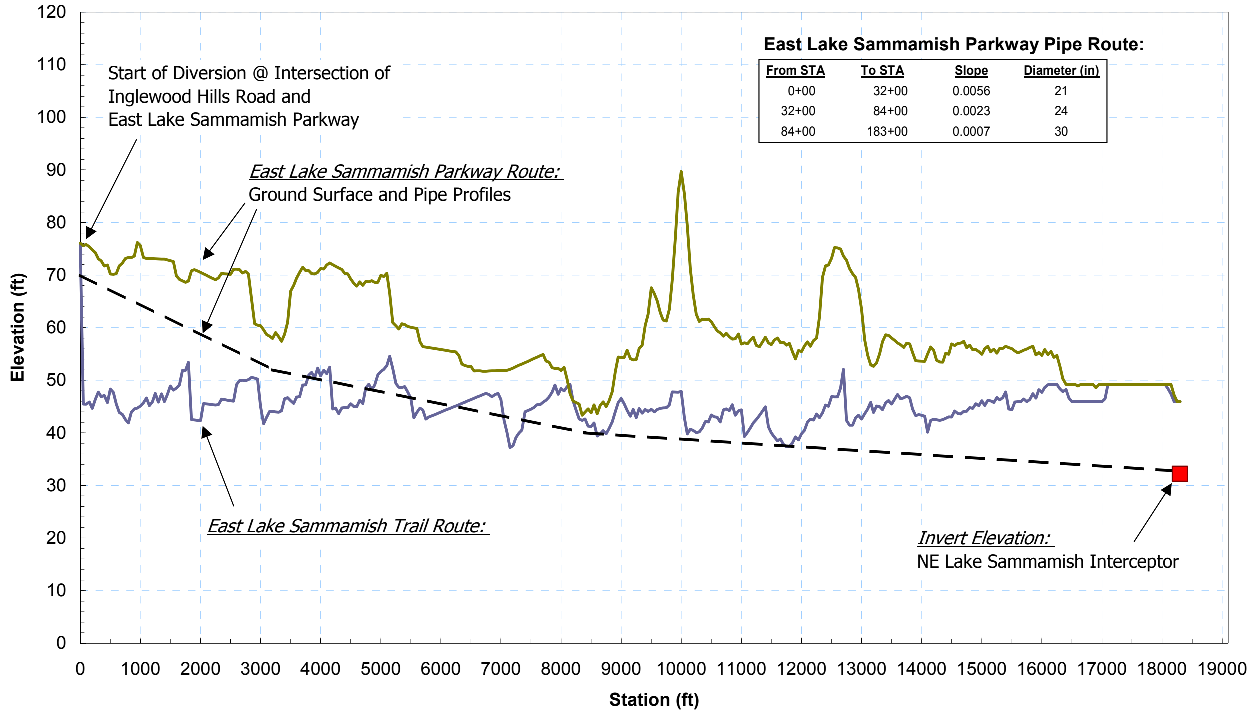


Figure 5. Ground Surface Profile for Alternative A Routes

The area near Lake Sammamish, where most of the trail and parkway routes are located, is mostly flat, and the grade that is available for a gravity sewer is limited. The East Lake Sammamish Trail route has little, if any, drop over the final 18,000 lineal feet. The East Lake Sammamish Parkway route drops only 25 feet over 18,000 feet and has intermediate high spots. Gravity flow along the parkway route could be maintained by running a tight line sewer for most of the route, allowing surcharging during large storms or by running a larger diameter pipe to maintain open channel flow at peak flows. A gravity pipeline of either type along the full length of the trail route may not be feasible, but a final determination cannot be made from the available planning data.

While the parkway route is more hydraulically workable than the trail route, the predesign team should study the trail route further, because the route would have advantages over the parkway alignment. Specifically, the trail route alleviates several serious construction challenges that would be faced constructing a pipeline along East Lake Sammamish Parkway. The trail route reduces the level of effort for traffic control, mitigating impacts to sensitive areas, avoiding or moving existing utilities, and other constraints. As a result, the trail route should entail a lower construction costs and fewer impacts to the public during construction than East Lake Sammamish Parkway alignment. However, the lack of grade differential along the trail route would likely preclude a gravity pipeline.

Pipe Diameter and Flow Velocity Range

The predesign team should give careful attention to the flow velocities, particularly in the near-term while the northern part of the Sammamish Plateau has large, undeveloped pockets. In the Task 240 report, the 2005 base flow was projected at 0.5 mgd. By 2050 the base flow will increase to 0.9 mgd. Assuming moderate growth between 2005 (the date used by Sammamish Plateau WSD for sewer customer forecasts) and 2010, the average dry weather flow will be about 0.6 mgd in 2010. At such a flow rate through a pipe with a mostly flat profile, maintaining velocities greater than 2 fps at low flow may not be feasible. However, meeting the Department of Ecology velocity guideline of 2 fps at full pipe flow is possible.

Table 3 lists the required pipe diameter needed for a gravity sewer, given the available slope for the parkway. Given limited grade and low velocities, the County should consider open-channel flow so the inspection and maintenance group can access and clean the sewer if necessary. The pipe profiles assume a minimum cover of 4 feet for the parkway route, and the downstream connection would be 6 inches above the invert at the beginning of the NE Sammamish Interceptor (32.2 feet above mean sea level, Metro datum).

Table 3. Northward Diversion Gravity Pipe Section Profile and Diameter[A]

Parkway Route	Slope	Diameter (in)	Peak Capacity (mgd)[B]	Velocity (fps) @ 0.6 mgd
0+00 to 32+00	0.0056	21	7.7	2.9
32+00 to 84+00	0.0023	24	7.0	2.1
84+00 to 183+00	0.00074	30	7.2	1.4

A. The minimum pipe slope assumes a minimum cover of feet for the parkway route. In addition, the downstream end of the diversion sewer would connect to the NE Lake Sammamish Interceptor 6 inches above the existing pipe's invert in order to prevent backwater during high flows.

B. The peak capacities of the proposed pipeline are higher than the projected 2050 peak-20 year flow of 4.9 mgd. The additional capacity provides a buffer in case the tributary area generates more wastewater than predicted or if more area is directed to the diversion sewer.

While some kind of pipeline along either of the proposed routes is technically feasible, selection of the trail route would likely require a pump station to move the flows. A hybrid route, following the parkway along the upper sections of pipeline and then moving along the trail for the lower sections may be also feasible. The predesign team should also conduct additional field work to determine if a modification to the trail route could produce increases slope in the pipeline. As this project moves forward, City of Sammamish officials should be consulted to see if there are any additional construction opportunities along East Lake Sammamish Parkway, as the City has preliminary plans for widening the East Lake Sammamish Parkway.

Issaquah Highlands Relief Sewer

The Working Alternative proposes to divert wastewater generated in Issaquah Highlands away from the Issaquah Creek Interceptor. This diversion (designated Alternative I in the Task 240 report) would not reduce flow to the Issaquah Interceptor lake line, but it would provide a relatively low-cost way to preserve capacity of this Issaquah Creek Interceptor, which will likely be the first sewer in the South Sammamish Basin to run out of capacity. In essence, the proposed diversion amounts to a bypass or "relief sewer" for the Issaquah Creek Interceptor. Diverting Highland flows past the Issaquah Creek Interceptor will allow that interceptor to convey peak 20-year flows beyond 2010.

The Issaquah Highlands is located east of downtown Issaquah on the ridge north of I-90. It is the site of a large, on-going residential and commercial development. Right now, the wastewater contribution from this area is relatively minor, but as the Issaquah Highlands development fills in, the amount of wastewater generated in the area will increase. The future flows from the Issaquah Highlands are expected to range from a 2010 dry weather base flow of 0.4 mgd to a 2050 peak flow of 1.4 mgd.

The refined analysis of the Highlands diversion includes the following:

- Identification of alternative alignments from the Issaquah Highlands to the Sammamish Plateau WSD pump station at SE 56th Street.

- A review of impacts of each alternative and coordination with Sammamish Plateau WSD and Issaquah staff.

Relief Sewer Alignment Alternatives

The CSI project team examined different routes to convey Issaquah Highland wastewater to the Sammamish Plateau WSD pump station located at the SE 56th Street and 221st Place SE. The team identified three alignments that would divert wastewater away from the Issaquah Creek Interceptor entirely by gravity flow. Each of the routes involves conveying wastewater through an existing Issaquah local sewer to a new diversion sewer that connects to the SPWSD SE 56th Street Lift Station. The routes vary in length and in the amount of traffic in the rights-of-way. This report does not discuss the issues of ownership transfer or local flow exchange agreements among Issaquah, Sammamish Plateau WSD, and King County. Those issues have been left for project predesign.

Figure 6 shows the diversion routes examined. Figure 7 shows the ground surface profile and proposed pipe profile along the routes, and Table 4 summarizes the pipe and hydraulic information. Table 5 lists the streets in each route. Similar to the proposed diversion of Sammamish Plateau WSD flows northward, the Highlands diversion routes are located in relatively flat areas. However, the slopes are sufficient to maintain a minimum velocity of 2 fps with the Highlands' base flow in 2010 of 0.4 mgd.

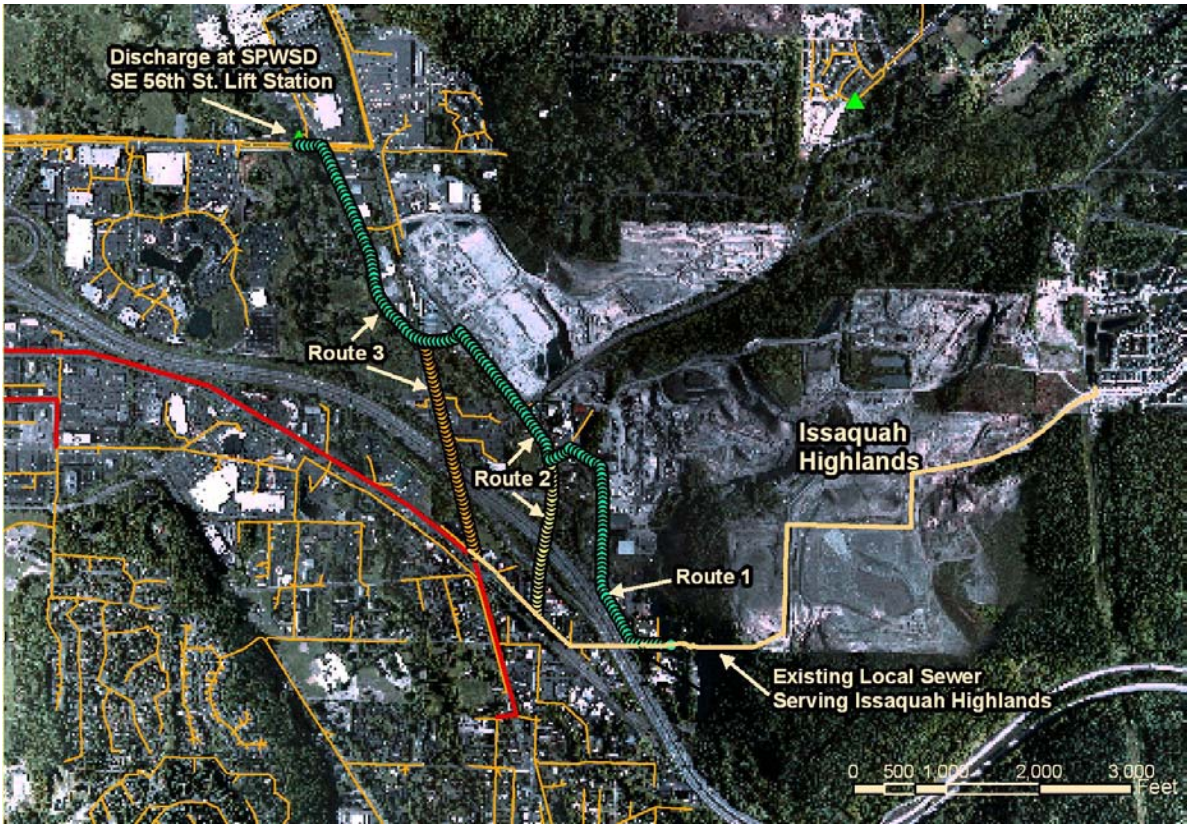


Figure 6. Possible Routes for an Issaquah Creek Interceptor Relief Sewer

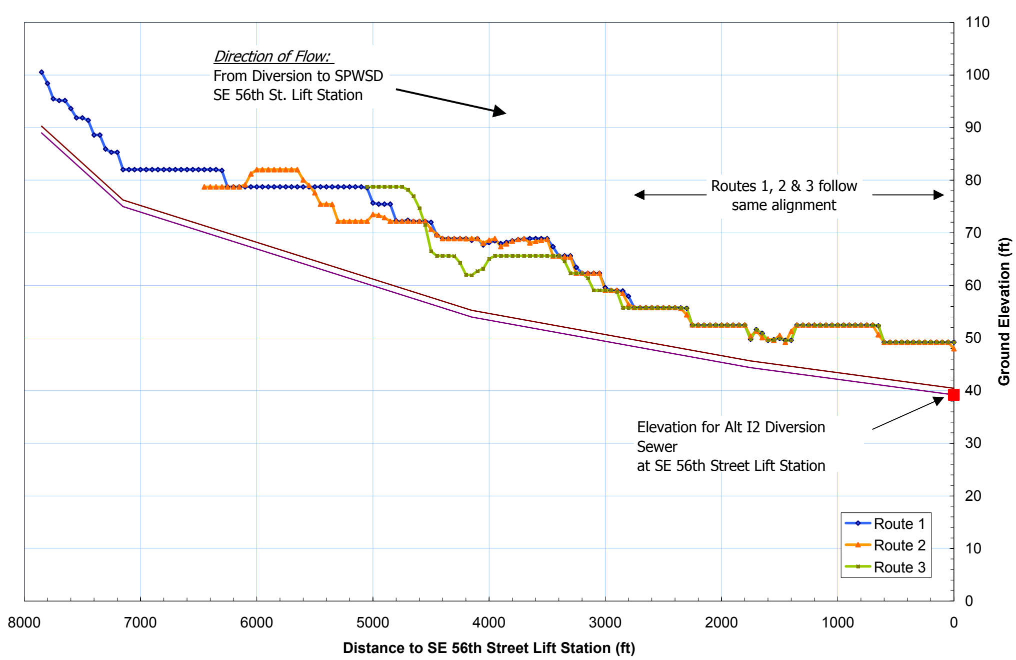


Figure 7. Ground Surface Profile and Pipeline Profile for Proposed Issaquah Creek Interceptor Relief Sewer

Table 4. Highlands Relief Sewer Piping Summary

Diversion Route	New Pipe Length (ft)	Minimum Pipe Slope	Average Pipe Slope	Diameter (in)	Peak Capacity (mgd)[A]	Velocity (fps) @ 0.4 mgd
1	7,850	0.003	0.005	15	2.3	2..2
2	6,450	0.003	0.005	15	2.3	2.2
3	5,050	0.003	0.006	15	2.3	2.2

A. By 2050, peak Highlands flows are expected to reach 1.4 mgd. The excess capacity provides a buffer if more wastewater comes from Issaquah Highlands than predicted or if additional area is diverted to the relief sewer.

Table 5. Highlands Relief Sewer Street Alignment Summary

	Street Alignment (Upstream to Downstream)
Route 1	NE Holly Street *to* 1st Avenue NE *to* 230th Avenue SE *to* SE 66th Street *to* 229th Avenue SE, then to East Lake Sammamish Parkway *to* E 62nd Street, then to 221st Place SE, then t*o* the SE 56 Street Lift Station
Route 2	Front Street *to* East Lake Sammamish Parkway, then to E 62nd Street *to* 221st Place SE, then to the SE 56 Street Lift Station
Route 3	North along easement across I-90, then to E 62nd Street, then t*o* 221st Place SE, then to the SE 56 Street Lift Station

The three alignments described above have sufficient grade for a gravity sewer. The minimum capacity of a 15-in diameter gravity sewer is 2.3 mgd, which is sufficient to convey the, peak 20-yr flow from the Issaquah Highlands[3] (estimated at 1.4 mgd when the area is fully developed to the planned density). Flow velocities under normal dry weather conditions would range from about 2 fps to 2.5 fps.

In evaluating the three routes, the third alignment would require the least new piping and have the lowest construction cost. This route would, however, cross private property and require the County to acquire permanent and construction easements. Routes 1 and 2 run in larger streets and could entail more traffic impacts and disruption than the third route. The project predesign team should evaluate the relative benefits of these routes.

Coordination with the Sammamish Plateau Water and Sewer District

The proposed Issaquah Creek Interceptor relief sewer might increase the flow to the Sammamish Plateau WSD's SE 56th Street Lift Station, depending on the route selected for a new connection between the District and King County conveyance systems. Two connection routes are being considered. One route would cross Lake Sammamish State

[3] The CSI project team computed the capacity of a 12-in diameter sewer at 0.003 slope at 1.3 mgd. This is not enough to meet the project peak 20-year flow from the Issaquah Highlands, and 15-in diameter is the next nominal size for reinforced concrete pipe.

Park and connect with the Issaquah Interceptor lake line. If the state park route is built, it will remove much of the area draining to the SE 56th Street Lift Station, and there will be excessive capacity to convey flow from the relief sewer. If a route along SE 56th Street is selected, the SE 56th Street Lift Station will have to be rebuilt, and its capacity can be increased to accommodate the Issaquah Highlands flow.

Peak Flow Storage in Issaquah and Sammamish Plateau

The CSI project team conducted a field visit to Issaquah and Sammamish Plateau to evaluate the potential for siting storage systems in these areas. When evaluating storage areas, the team tried to eliminate areas with high groundwater that could affect construction or operation of a tank and looked for areas where the elevation was suitable for facility filling and draining by gravity.

Two storage configurations could be designed for simple operation, minimal maintenance (self-cleaning), and minimal impact (odor control) on surrounding land uses. The two configurations–cast-in-place, concrete tanks and tunneled conduits–differ primarily in their construction techniques. The selection of configuration will depend on site constraints and overall costs.

Near downtown Issaquah, there are several locations for building storage tanks and staging areas for building a tunnel. Generally tunnels are recommended because of lower maintenance and the potential for building within a public right-of-way. The final siting of storage facilities should be completed by the predesign team.

The CSI project team found few suitable locations in the lower portion of the Sammamish Plateau WSD service area for peak flow storage. One possible site is the District's control structure property located on SE 43rd Way, on the hillside above East Lake Sammamish Parkway. The site is shown in Figure 8. A storage facility capable of storing 1 million gallons (MG) could be constructed on that site if the storage unit is 35 feet deep. If the facility spans onto adjacent undeveloped property, the total storage can be increased. Because the site is on a hillside, the design could incorporate self-cleaning features that would greatly reduce maintenance requirements. The results of the CSI project team evaluation of this site are included as Appendix B.

Figure 8. Potential Storage Site at the Sammamish Plateau WSD Control Structure

Minor Upgrades to the Sunset PS and Heathfield PS

In discussion with King County staff, the CSI project team learned the Sunset and Heathfield Pump Stations maximum pumping capacity is currently estimated to be 18 mgd. The CSI project team noted that increasing the capacity a small amount, to about 21 mgd, would allow the station to convey the peak 20-year flow once the Working Alternative is implemented. At the February Decision Workshop, King County staff indicated the peak capacity could be increased through minor upgrades.

PART 3: ADDRESSING SPECIFIC ISSUES RAISED AT THE DECISION WORKSHOP

Impacts of Peak Wastewater Flow that Vary from Current Projections

The Working Alternative describes a plan for staging conveyance improvements over two decades. The timing and the sizing of conveyance upgrades is linked to the County's wet weather peak flow projections. These projections are themselves based on model calibration to collected flow data, assumptions about future I/I rates, assumptions about sewer degradation, and growth forecasts. By continuing to monitor flows and refining the flow and sewered population projections, the County will be able to reduce the uncertainty about the timing and size of future conveyance facilities.

The alternative packages presented at the South Sammamish Basin Decision Workshop attempted to balance the short-term need for increased conveyance capacity and the long-term uncertainty regarding population growth and peak wet weather flow. In developing the alternative packages, one goal was a solution that would remain viable if future flows are different from the projections. The facility upgrades early in the program will be necessary and are appropriately sized, even if future flows are higher or lower than projected. The size of the facilities constructed later in the program can be adjusted to meet future demand.

In response to King County comments, the project team conducted a sensitivity analysis to determine whether the Working Alternative could me adapted to population and flow scenarios that differ from those used in Task 240. The sensitivity analysis memo is summarized below and reproduced in full as Appendix C.

Most of the uncertainty in the future flow predictions derives from the amount of unsewered land[4] in Issaquah and the Sammamish Plateau. The future "to-be-sewered" areas generate uncertainty over when the sewers will come online and how much I/I will these new systems admit. Four scenarios were developed to gauge the impact of development on future wet weather flows and the South Sammamish Basin Working Alternative (Table 6). The scenarios each represent higher or lower growth and I/I generation rates, and together they represent the likely range of future development and flow conditions in the upstream portions of the South Sammamish Basin.

[4] The unsewered land is either undeveloped area within the urban growth area that will develop in the future, or land that has been developed already but is served by onsite septic systems.

Table 6. Future Growth and Flow Scenarios for Issaquah & Sammamish Plateau[A]

Scenario	Issaquah			Sammamish Plateau		
	Sewered Population Growth	Existing & Future I/I Rate	Fully Sewered	Sewered Population Growth	Existing & Future I/I Rate	Fully Sewered
1. High Issaquah & Sam Plateau	+20%	+33%	2010	+20%	+33%	2010
2. High Issaquah	+20%	+33%	2010	-	-	2020
3. High Sammamish Plateau	-	-	2020	+20%	+33%	2010
4. Low Issaquah & Sam Plat	-20	-33%	2030	-20	-33%	2030

A. The scenarios defined are relative to the flow projections in the Task 240 report. The high growth scenario includes 20% higher population (and base flow) than forecasted in each decade, I/I rates one third higher than predicted and a faster schedule to full sewering.

Figure 9 shows how projected basin flows vary with variations in the rate of future growth. Through a combination of rapid growth, sewer expansion, and higher I/I rates, Scenario 1 predicts as much as 13 mgd more than the Task 240 flow projections in 2010[5] for the peak 20-year flow, although that difference narrows later in the planning period. Scenario 4, which reflects reduced and delayed development, predicts as much as 10 mgd less than the baseline flow projection for the peak 20-year flow in 2020.

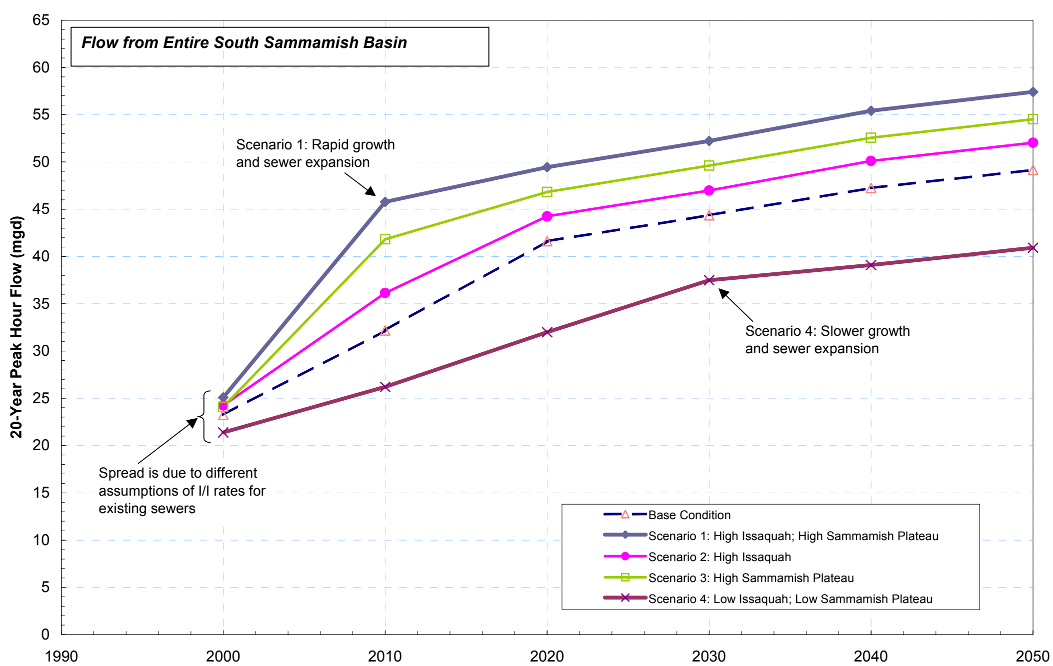


Figure 9. Range of Flows in South Sammamish Basin

[5] The Task 240 projections were based on PSRC population forecasts and are considered the "base condition" in Figure 9.

While Scenarios 1 and 4 represent an outer range of future flows, the future development/flow condition will probably be closer to that presented in the Task 240 report, because the Task 240 projections are based on the best available growth forecasts from the County and local agencies on and the best available flow data.

The key issue is how differences in the rate of population growth, I/I rates, and sewer service expansion affect when additional capacity will be needed. Table 7 lists the County's current schedule for upsizing the conveyance capacity in the basin as determined in Task 240 and how the schedule would be altered if the future flow differs significantly from the Task 240 flow projections. The table is similar to Table 21 in the Task 240 report Table 7 provides perspective on how the schedule of facility upgrades and the amount of increased capacity (or flow reduction) that would be needed under than extreme high and low scenarios of Scenarios 1 and 4.

Table 7. Schedule of Facilities Reaching Capacity

Conveyance Facility	Scenario	When Additional Capacity Needed	Additional Capacity Needed in 2010/ 2020[A]	Additional Capacity Needed in 2050 [A]
Issaquah Creek Int.	Scenario 1	2010	2.4 / 2.8 mgd	3.9 mgd
	Task 240	2010	0.3 / 1.6 mgd	2.4 mgd
	Scenario 4	2030	0 / 0 mgd	0.9 mgd
Issaquah Int. Sec. 2	Scenario 1	2010	10.6 / 13 mgd	19.1 mgd
	Task 240	2020	0 / 6.2 mgd	11.8 mgd
	Scenario 4	2030	0 / 0 mgd	2.6 mgd
Issaquah Int. Sec. 1	Scenario 1	2010	13.3 / 15.7 mgd	21.8 mgd
	Task 240	2020	0.4 / 8.9 mgd	14.5 mgd
	Scenario 4	2030	0 / 0 mgd	5.3 mgd
Sunset P.S.	Scenario 1	2010	18.1 / 21 mgd	28.1 mgd
	Task 240	2010	5.2 / 14.2 mgd	20.9 mgd
	Scenario 4	2020	0 / 3.6 mgd	11.6 mgd
Heathfield P.S.	Scenario 1	2010	18.1 / 21 mgd	28.1 mgd
	Task 240	2010	5.2 / 14.2 mgd	20.9 mgd
	Scenario 4	2020	0 / 3.6 mgd	11.6 mgd

[A] The additional capacity needed values assume the upstream facilities convey all wastewater to the given interceptor pump station. If there is a reduction in flow upstream, the effects will cascade through the conveyance system downstream

[B] Sunset and Heathfield Pump Stations need 8.2 mgd of additional capacity in 2010 and 17.2 mgd in 2020. The calculations are based on capacity test at Sunset Pump Station that showed a peak throughput of 21 mgd. The working alternative assumes peak throughput can be increased to 21 mgd through minor station improvements.

If the basin develops according to Scenario 1, more capacity will be needed than was included in the Working Alternative, and the capacity increases will be constructed sooner. For example, the facilities listed in Table 7 will require approximately 6 to 7 mgd of additional capacity in 2020 beyond what is projected using the Task 240 peak flow rates.

This higher than predicted demand could still be managed, if King County adapts the Working Alternative to these higher demands. The basic framework of the Working Alternative would still apply: (1) divert some Sammamish Plateau flow north, (2) provide relief to the Issaquah Creek Interceptor, (3) use a combination of storage and I/I control to preserve the capacity of downstream facilities. Under Scenario 1, more Sammamish Plateau flow would be diverted to the north and the remaining additional demand would be managed through a combination of aggressive I/I control and larger storage facilities. The conveyance upgrades shown in Figures 2 and 3 would still apply, but the facilities would be designed to manage larger flows. Conversely, the slower growth and tighter sewers of Scenario 4 allow the storage and I/I control aspects of the Working Alternative to be delayed.

The sensitivity analysis examines the impacts of higher or lower peak flows on the implementation of the Working Alternative. It confirms that facility upgrades will be necessary, even if the actual growth and development rates prove to be lower than forecasted in Task 240. If peak flow rates increase faster than predicted in the Task 240 report, facilities would need to be brought online sooner, and the additional demand could be met with larger storage units and/or a larger diversion north from the Sammamish Plateau.

Operation and Maintenance Assumptions

At the Decision Workshop, King County staff requested a more detailed analysis of the operation and maintenance (O&M) costs of each of the components of the Working Alternative. The participants noted that capital and operation costs are issues that should be identified separately for a better understanding of the impacts and staffing requirements of the planned facilities. Additionally, when comparing the total cost conveyance of facilities over their lifespan, operation and maintenance is an important part of the total cost, and the combination of maintenance costs and staffing requirements could be a determining factor in the evaluation of proposed wastewater facilities. This section summarizes an operation and maintenance memorandum that was prepared for King County staff and is included as Appendix D.

The County has years of pipeline maintenance cost data on which to base O&M cost estimates for pipelines. The County has less experience with storage facilities, and the storage facility O&M costs cannot be estimated form accumulated records. Storage facility O&M was discussed with King County staff during preparation of this report, and the storage facility O&M cost estimates in this report were based on those discussions and on O&M costs for storage facilities as estimated in the *Combined Sewer Overflow Control Project 1995 Update* (*1995 CSO Update*).

For the operation and maintenance cost estimates, the CSI project team assumed storage facilities could be designed for simple operation, minimal maintenance (self-cleaning)[6]. Table 8 summarizes the inputs used to generate the O&M cost estimate for a hypothetical 1.5 MG tunnel and 26,000-foot long pipeline. In this example, it is assumed that the storage tunnel will be used once per year.

Table 8. Storage Facility O&M Cost Estimate Inputs

O&M Cost Component	Annual Cost[A]
1.5 MG Storage Tunnel (used once per year)	
Off-Line Storage Pipes Maintenance Cost	$2,300 per year
Off-Line Storage Pipes Inspection Cost	$800 per year
Total Storage O&M Cost:	$3,100 per year
Gravity Sewer:	
Inspection, Cleaning, Repair	$1 per ft per yr
Total Gravity Sewer O&M Cost:	$26,000 per year
Total O&M for Working Alternative	**$32,200 per year**

A. Note that bold values are changed from the *1995 CSO Update* spreadsheet; all other values are unchanged.

The annual pipe maintenance costs ($1 per foot per year) included in Table 8 are based on the 2000 budget report from the County's Sewer Inspection, Cleaning, and Repair Program.

Possibility of Increasing Storage to Eliminate the Northern Diversion

During the Decision Workshop, King County staff asked if the diversion of Sammamish Plateau flows to the NE Lake Sammamish Interceptor could be avoided by adding larger amounts of storage in the Sammamish Plateau WSD service area. The CSI project team had not pursued this alternative while developing the Task 240 report for the following reasons:

1. The Sammamish Plateau WSD system has a relatively small amount of I/I. This generates a rainfall-runoff response in the area characterized by wider hydrographs rather than narrow, high-peaked hydrographs typical for areas with direct inflow connections. In other words, a tighter system generally has a higher total-volume-to-peak-flow ratio than a leaky system. Thus, reducing the peak flow by a given percentage in a relatively

[6] Earlier in the report, there is a discussion of storage on the Sammamish Plateau, which was carried into greater detail than the other storage options. The Sammamish Plateau storage option was developed further, because King County had an opportunity to acquire property and facilities in the South Sammamish basin that would benefit this project and wider King County flow management goals. The likely storage facility for this site is a storage tank. The layout of the property where the tank could be built and the considerable relief to the downstream side of the property would allow for a more self-cleaning design, and operation and maintenance costs.

tight system requires more storage than reducing the same peak flow by the same fraction in a leakier basin.

2. Because of the difficulty the project team had locating a single suitable storage site on the Sammamish Plateau, it appears unlikely that the necessary storage volume could be feasibly sited there unless a series of distributed storage vessels were located throughout the Plateau. Distributing storage among many small vessels would greatly compound the O&M effort required.

The Working Alternative seeks to limit the future peak 20-year flow from the Sammamish Plateau to about 9.5 mgd in order to preserve capacity in the Issaquah Interceptor Section 1. Achieving this reduction by storage alone would force storage during relatively infrequent storm events. For example, given the projected 2050 average daily base flow is 4.1 mgd, storms that generate more than 550 gallons per acre per day (gpad) of I/I (over the future 10,175 sewered acres) would require storage. If the storm occurred during a high part of the diurnal base wastewater curve, even less I/I would produce a storm that requires storage.

Because the downstream flow limit is close to the projected base flow, this solution would be sensitive to the small differences in the King County and Sammamish Plateau WSD flow projections (see the Task 210 report). The Sammamish Plateau WSD use higher future base wastewater flow projections, assuming base flow will reach about 7 mgd by 2050 (although the future peak flow projections from the District are similar to King County's projections, because the District assumes lower I/I rates). If the future base flow is close to Sammamish Plateau WSD's predicted rate, the number of storage events and the required maintenance would make this option unfeasible.

For the reasons described in this section, the CSI project team does not recommend replacing Alternative A with additional storage in the Working Alternative.

PART 4: REVISED COST ESTIMATES AND CONSTRUCTION SCHEDULE FOR IMPLEMENTING THE WORKING ALTERNATIVE

This section of the report includes updates to the construction, project, and operation and maintenance costs prepared for the Task 240 report and the Decision Workshop (see Appendix A). The Sammamish Plateau diversion and Issaquah Highlands diversion costs are updated, because the different pipe length and diameter affect the total construction and project cost (Table 9). As with earlier cost estimates, this report uses Tabula, v1.0 conveyance system cost estimation software and an assumed *Engineering News Record* Construction Cost Index (ENR CCI) of 7,341, which is the Seattle index value for 2001. The cost estimates details are included in Appendix E.

Table 9. Updated Construction Cost for Northern Diversion and Issaquah Highlands Relief Sewer

	Construction Cost[A]
East Lake Sammamish Parkway Route	**$9,100,000**
Highlands Relief Sewer Route 1	$2,500,000
Highlands Relief Sewer Route 2	$2,100,000
Highlands Relief Sewer Route 3	$1,600,000
Highlands Relief Sewer Construction Cost Range	***$1.6 to $2.5 million***

A. Construction costs assume the 2001 Seattle ENR CCI of 7,341.

The elements of the Working Alternative can be constructed in a phased schedule, just-in-time approach. The CSI project team put together a proposed construction schedule to have facilities operating in time to meet the future peak 20-year flow. Table 10 lists the construction schedule, as well as construction and project capital costs, and annual operation and maintenance estimates. The operation and maintenance costs are updated using the revised unit costs developed in cooperation with King County staff.

Table 10. Working Alternative Project Costs

Alternative	Construction Cost[A]	Project Cost[B]	Annual O&M Cost[C]
Sammamish Plateau Diversion north[D]	$9,100,000	$19,500,000	$18,300 / year
Minor pump station improvements	$500,000	$1,100,000	N/A[E]
Issaquah Highlands Relief Sewer[D]	$2,500,000	$5,400,000	$7,900 / year
Sammamish storage	$8,500,0000	$18,300,000	$3,100 / year
Issaquah Storage	$8,500,0000	$18,300,000	$3,100 / year
Working Alternative Total	**$29,100,000**	**$62,600,000**	**$32,400 / year**

A. Construction costs were calculated using Tabula v1.0 with an assumed 2001 Seattle *2* CCI of 7341

B. Project costs include the following allied costs provided to the CSI project team by King County: sales tax = 8.8% of construction, design engineering = 20% of construction, construction management engineering = 12% of construction, labor = 16.8% of construction, closeout = 1% of labor, other costs = 1% of labor, land and ROW acquisition = 6.5% of construction, contingency = 30%.

C. For details, see Operation and Maintenance Assumptions section of this report

D. Assumes the most expensive of the routes identified.

E. The minor capacity improvements at the Sunset and Heathfield Pump Stations would only be used in extreme storm events. As a result, the CSI project team expects there would not be a measurable increase in station operation and maintenance.

While implementing the Working Alternative, King County should use the results of the regional I/I plan and updated flow projections to compare the benefits and costs of building the second stage of storage (scheduled at to occur in 2020 under the Working Alternative) versus the potential for I/I control. (The costs listed in Table 10 assume no I/I control in Issaquah.)

The planning-level flow and cost analysis in this report provides a basis for preliminary comparison of storage and I/I control. For example, if I/I control reduces the peak flow from Issaquah by 2.5 mgd (from a peak 20-year flow of 12.2 mgd), the storage facility in Issaquah can be sized at 0.7 MG rather than 1.5 MG. According to cost estimates in Tabula, the project cost savings from reducing the size of the storage facility is $5.2 million (using 2001 Seattle ENR CCI of 7,341). In other words, the cost of storage peak flows in Issaquah and Sammamish Plateau is about $2.10 per gallon of the peak 20-year flow removed, which is at the low end of the I/I removal costs given in the Task 250 report. Beyond 1.5 MG of storage in Issaquah and Sammamish Plateau, the peak flow rate reduction per gallon of storage ratio declines and the cost of reducing flow via storage increases.

PART 5: IMPLEMENTING THE PLAN – SUMMARIZING NEXT STEPS

This report provides a refined analysis of the Working Alternative to upgrade conveyance facilities and manage wastewater conveyance in the South Sammamish Basin until 2050. To summarize, the Working Alternative includes the following elements:

- Diversion of up to 5 mgd of Sammamish Plateau WSD flows north to the NE Lake Sammamish Interceptor.
- Relief sewer to keep up to 1.4 mgd of Issaquah Highlands flows out of Issaquah Creek Interceptor.
- Peak flow storage in Issaquah and in the Sammamish Plateau.
- I/I reduction in the Issaquah 1 and Issaquah 2 modeling basins.
- Minor improvements to the Sunset and Heathfield Pump Stations designed to increase pumping capacity to 21 mgd.

The Working Alternative can be implemented in a phased approach, which will give King County staff an opportunity to revisit the alternative components and fine tune the facility sizes to match of level of development in the service area and to incorporate the impacts of specific I/I removal programs. While the components of the Working Alternative are described in enough detail to transfer to King County's CIP group, the following will be required during project predesign:

1. Review the two alignments described here to transfer flow north from the Sammamish Plateau (Alternative A) and develop a final route.

2. Examine the three routes proposed for the Highlands relief sewer and develop a final route. Also, coordinate with the Sammamish Plateau WSD as its comprehensive plan is adopted so the impacts of the Highlands relief sewer are mitigated.

3. Finalize the siting of the Issaquah storage facilities. Investigate whether all of the Sammamish Plateau storage can be sited at the SE 43rd Way Sammamish Plateau WSD control structure property.

4. Consult the environmental review of the Working Alternative (see Appendix F) for sensitive areas and permitting requirements.

APPENDIX A: SYSTEM ALTERNATIVES DECISION WORKSHOP

South Sammamish Basin: System Alternatives Decision Workshop

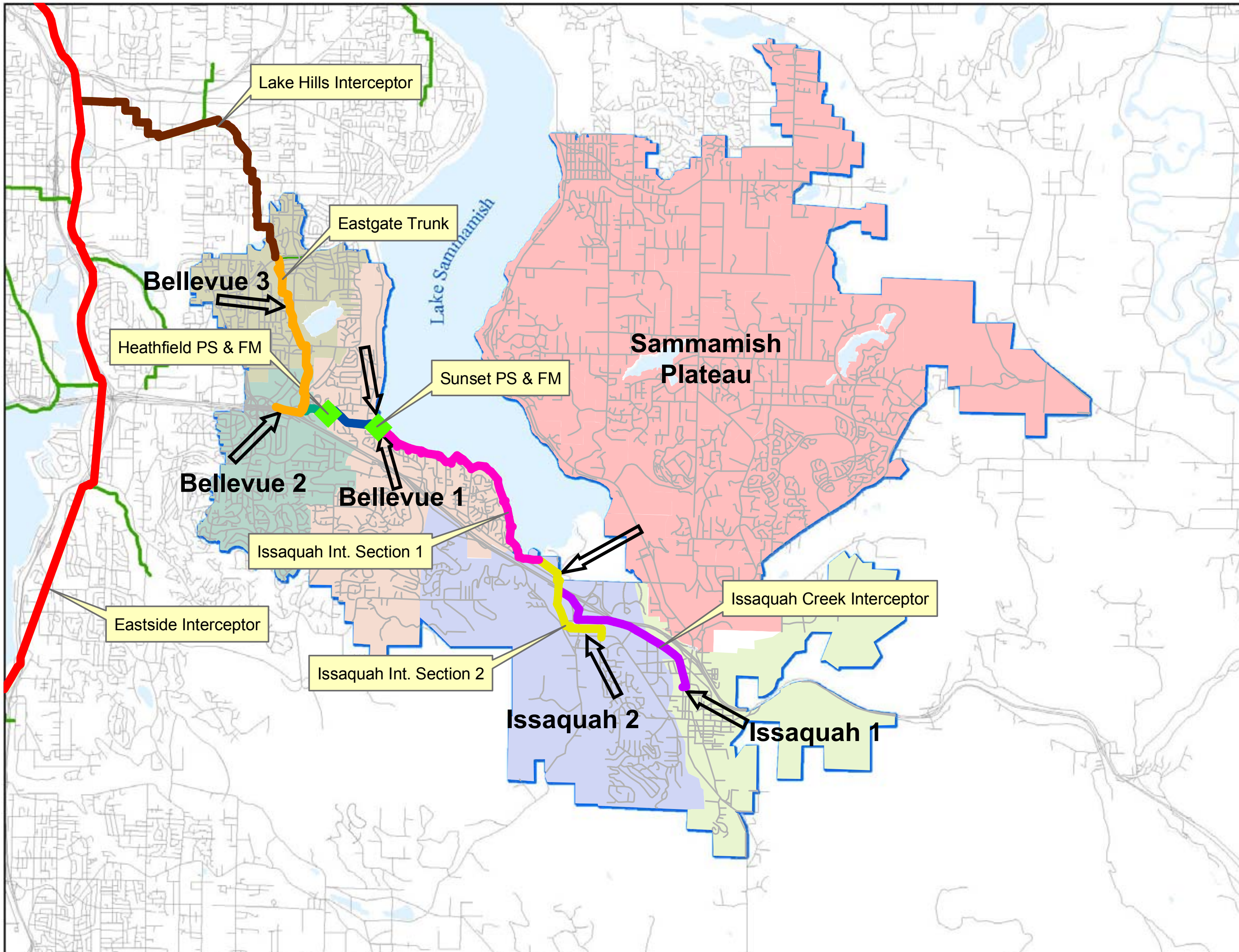
February 11, 2002

Today's Objectives

- Present the information that was developed as part of the CSI Project for the South Sammamish Basin
  - Description of South Sammamish Basin and Existing Facilities
  - Flow Projections Compared to Existing Capacity
  - Existing System Capacity Shortfalls
  - Review Alternatives
  - Review Alternative Packages
  - Description of Recommended Working Alternative
- Discussion of Alternative Packages
- Reach Agreement on the "Preferred Working Alternative"
- Clarification of outstanding issues/concerns (250 report)

South Sammamish Basins and Existing System

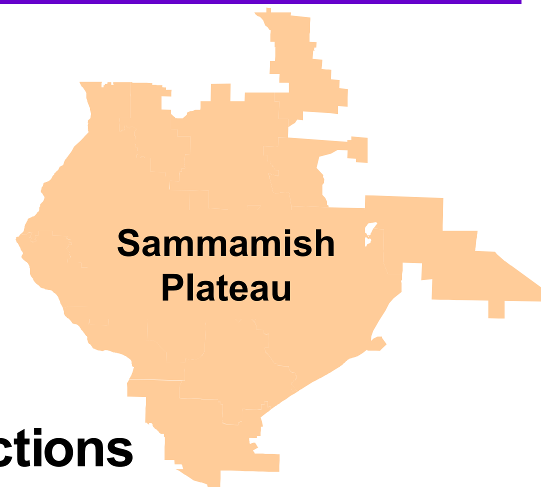
South Sammamish Basins and Facilities



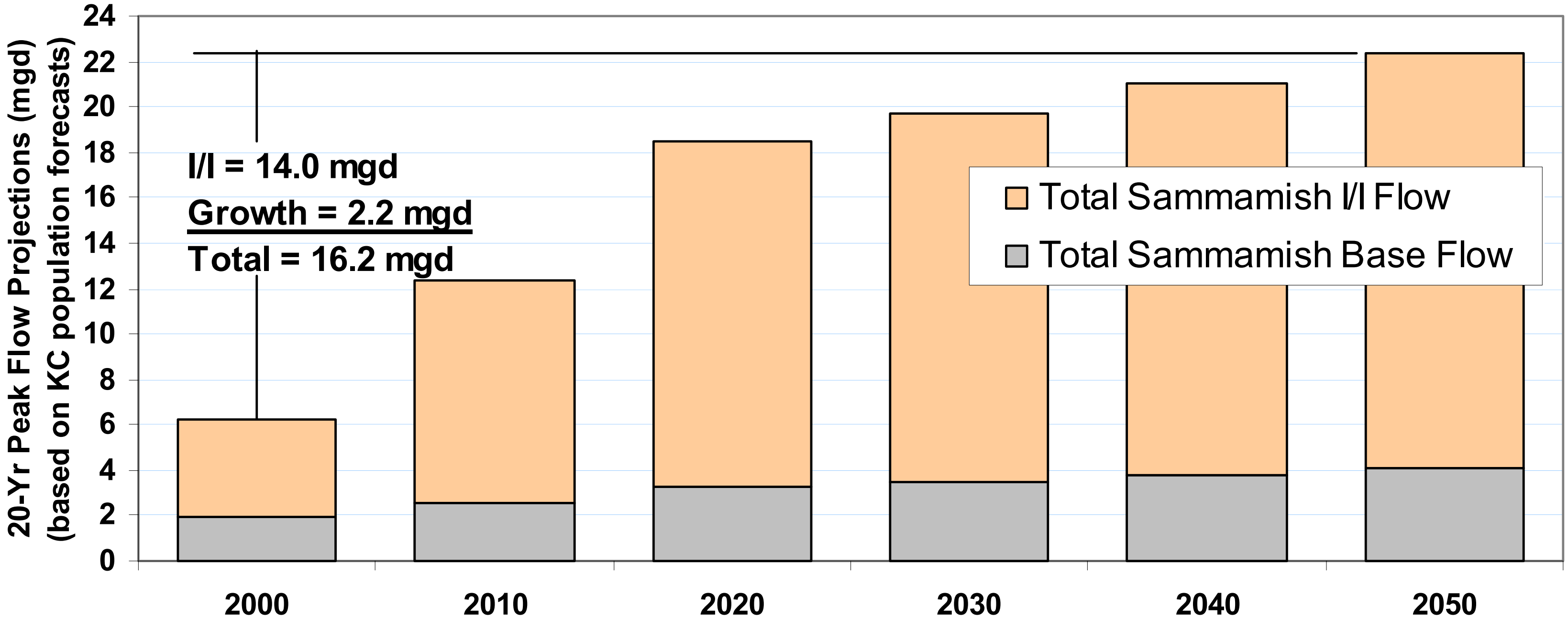
South Sammamish Basin Flow Projections and Existing Facility Capacity

King County Department of Natural Resources and Parks

Conveyance System Improvements Project
South Sammamish Basin

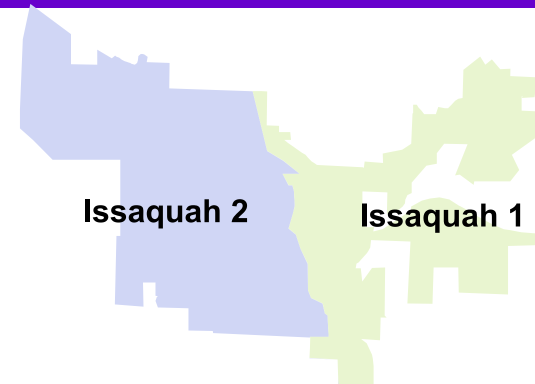


Sammamish Plateau Peak Flow Projections

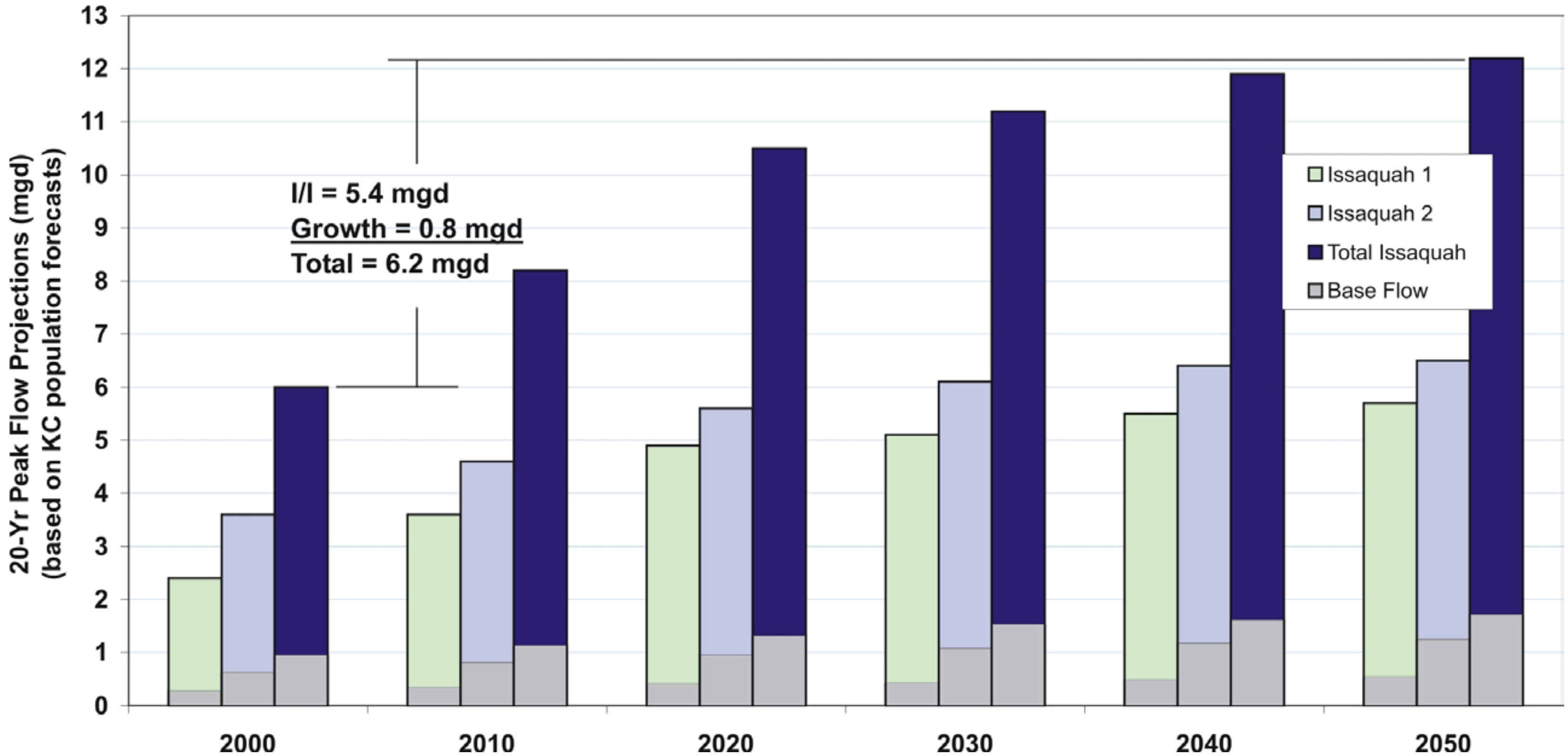


King County Department of Natural Resources and Parks

Conveyance System Improvements Project
South Sammamish Basin

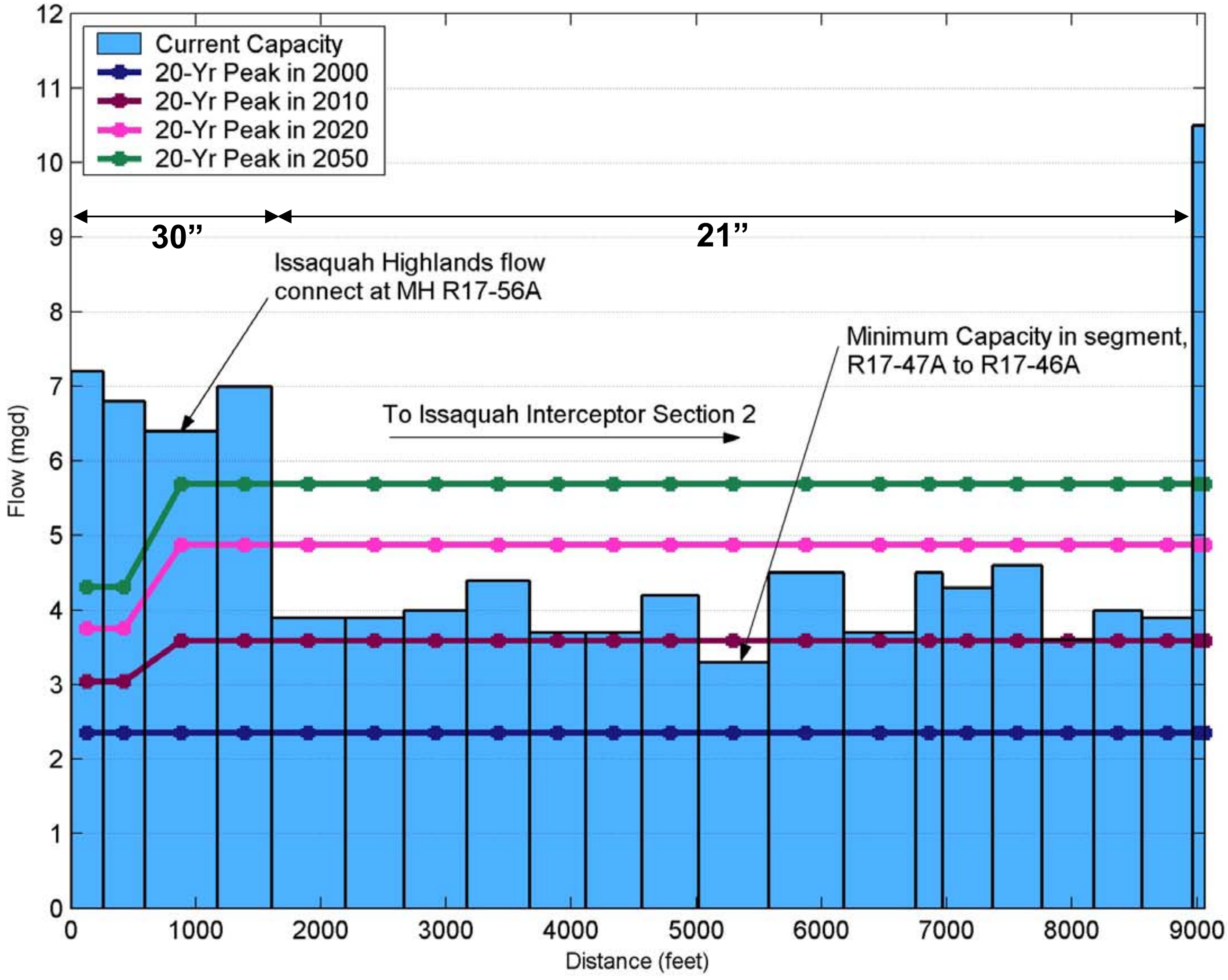


Issaquah Peak Flow Projections

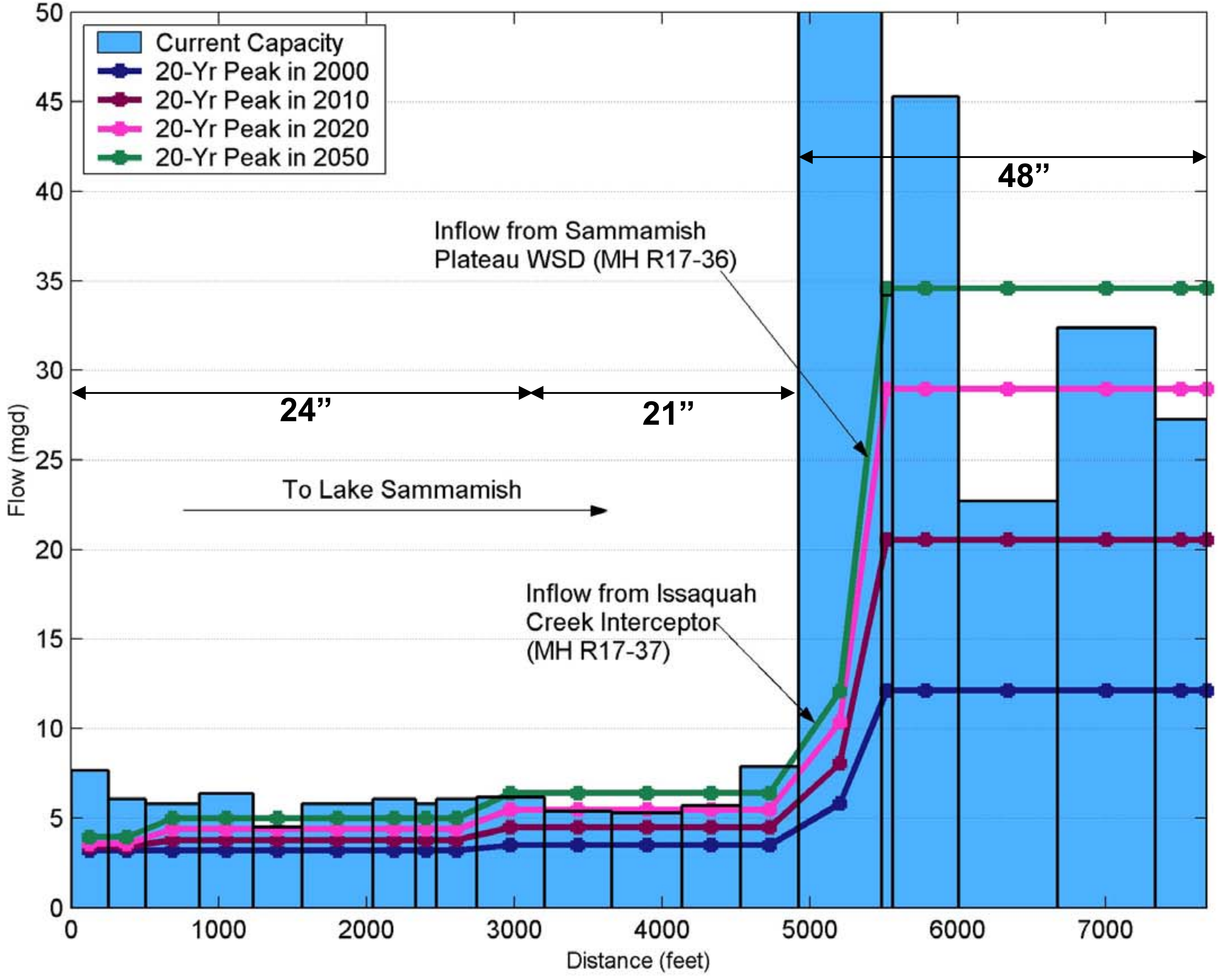


HDR
BROWN AND CALDWELL

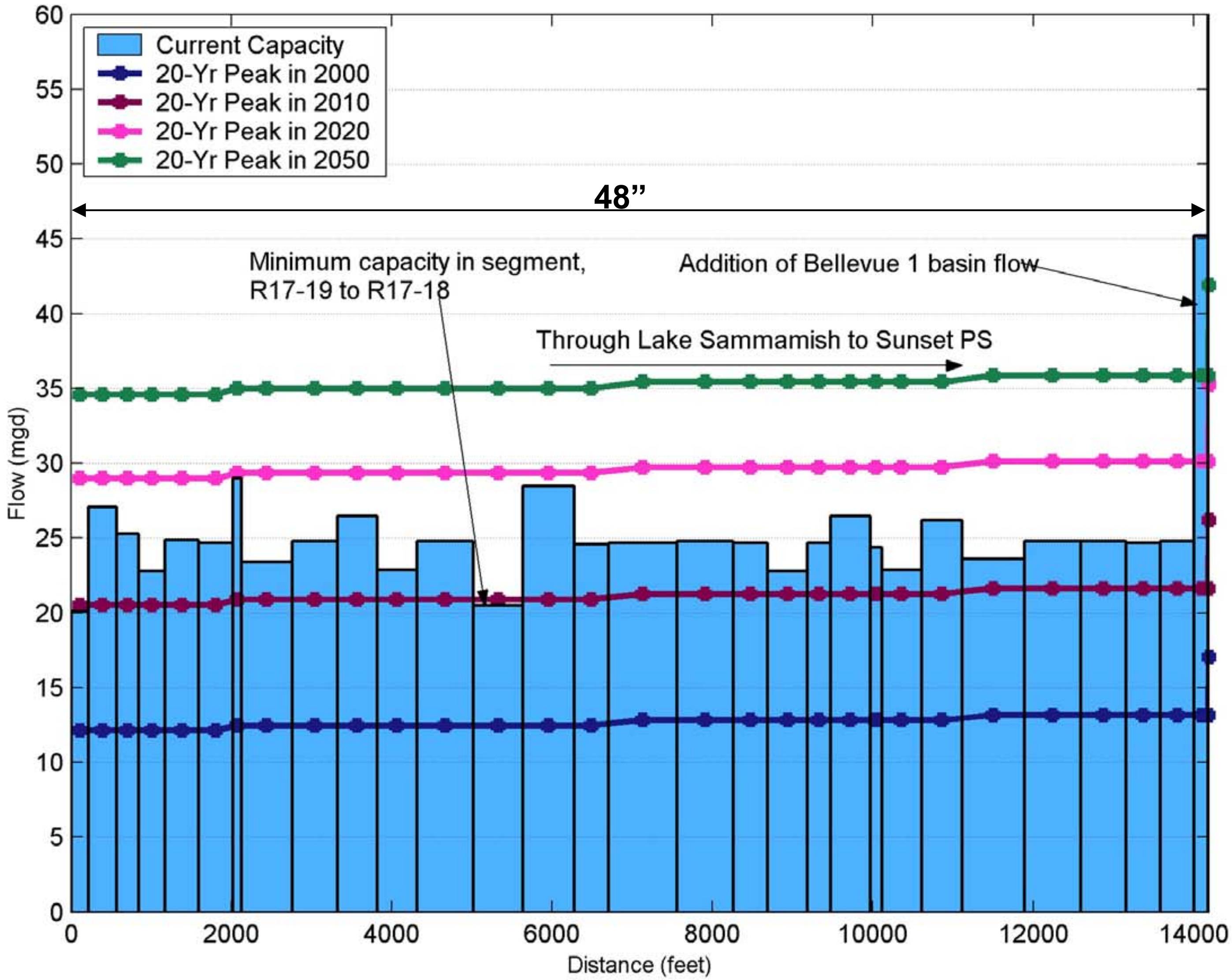
Issaquah Creek Interceptor

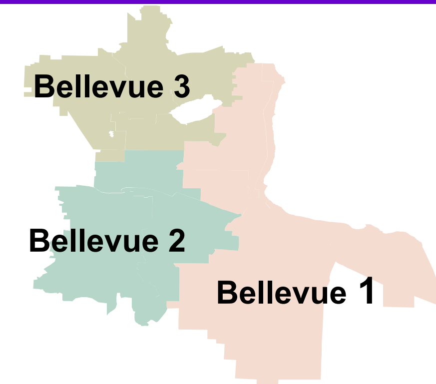


Issaquah Interceptor Section 2

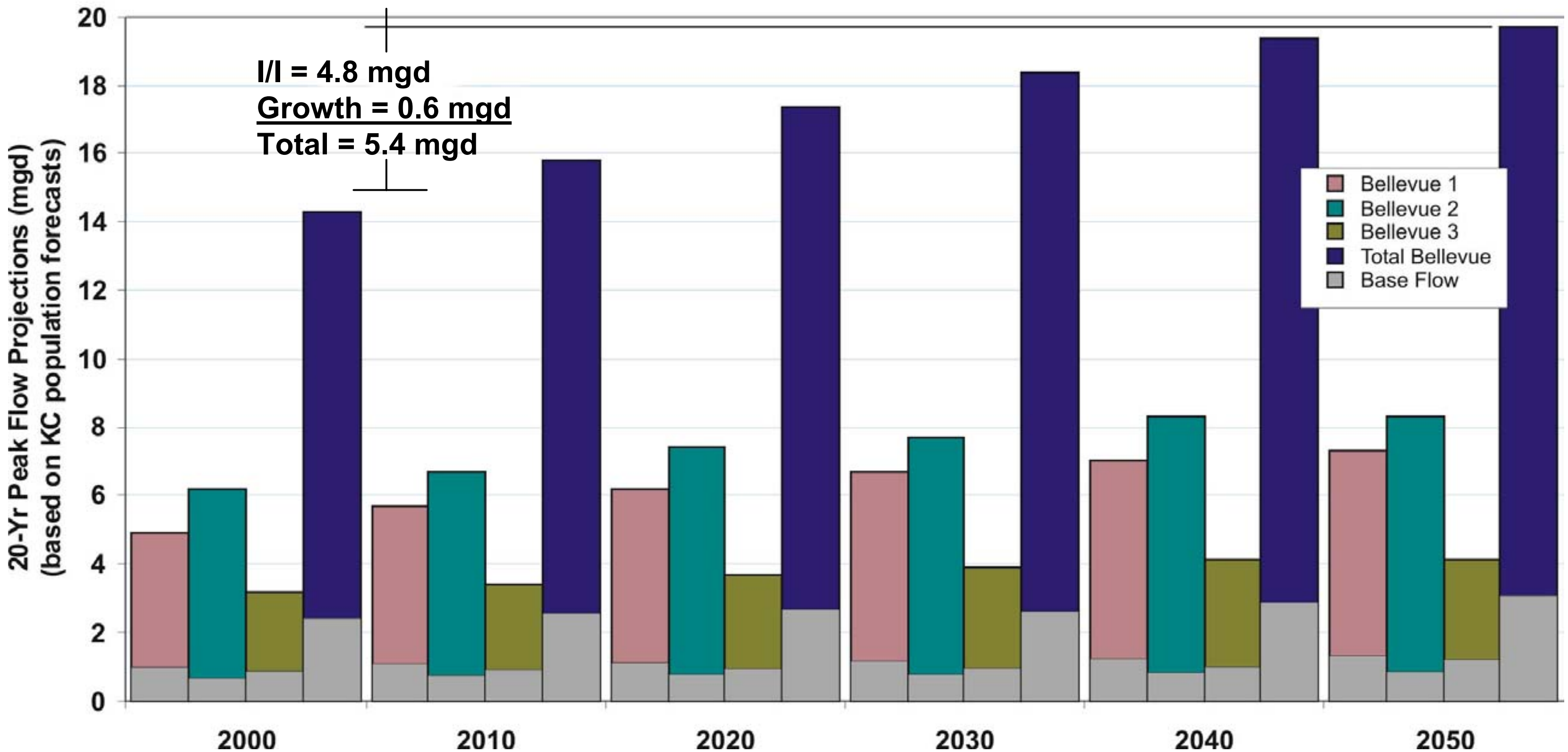


Issaquah Interceptor Section 1

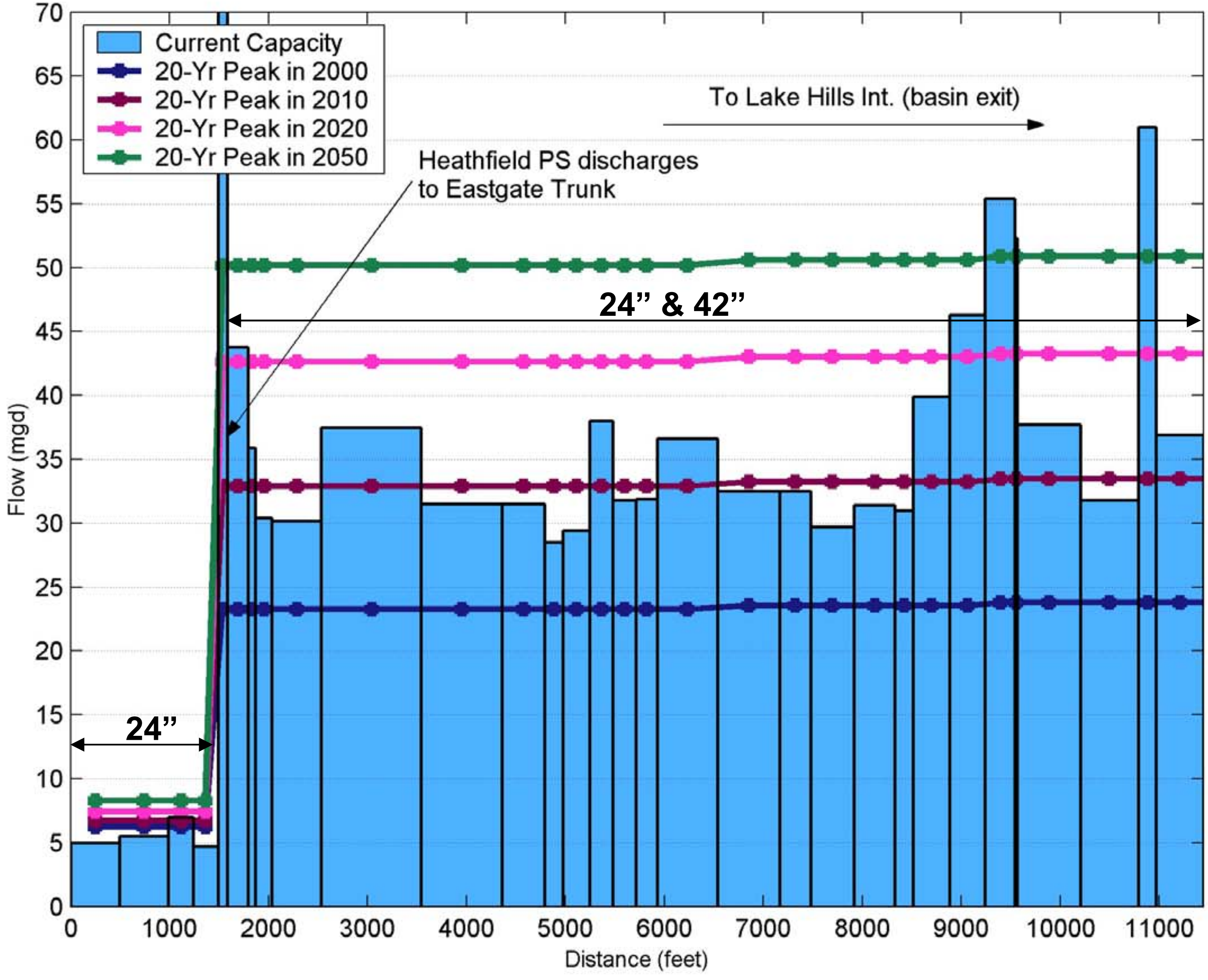




Bellevue Peak Flow Projections

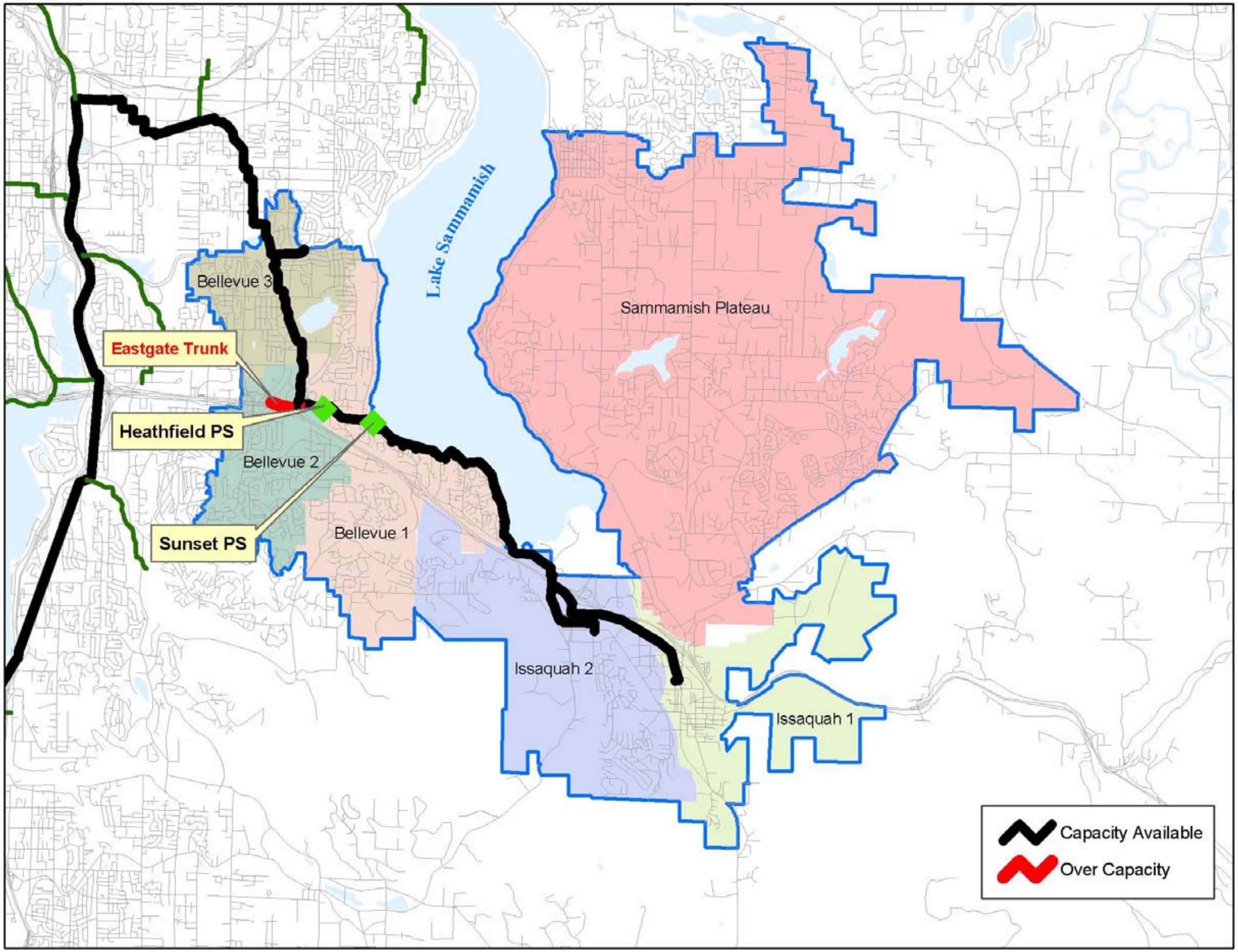


Eastgate Trunk



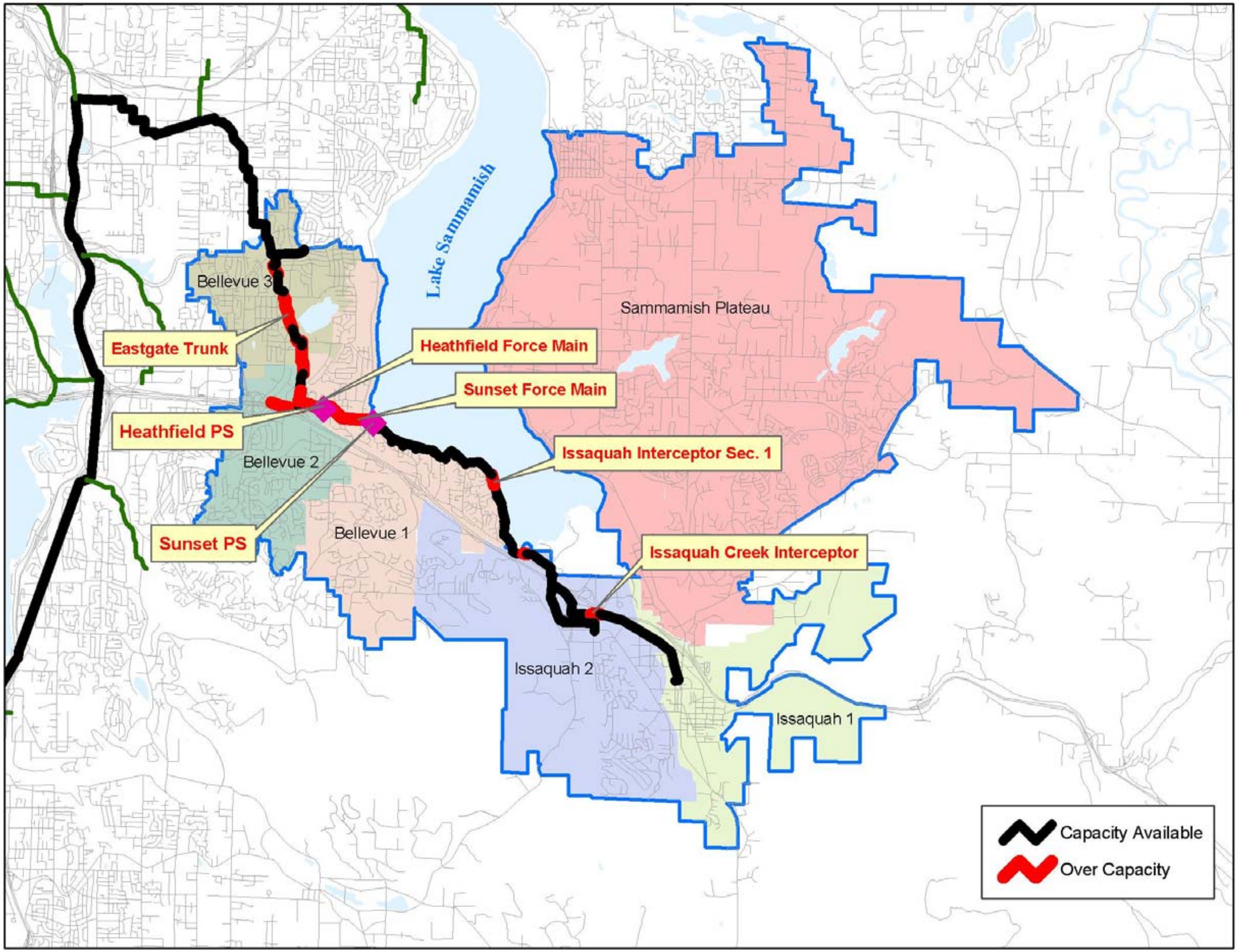
South Sammamish Basin Capacity Shortfalls

Year 2000



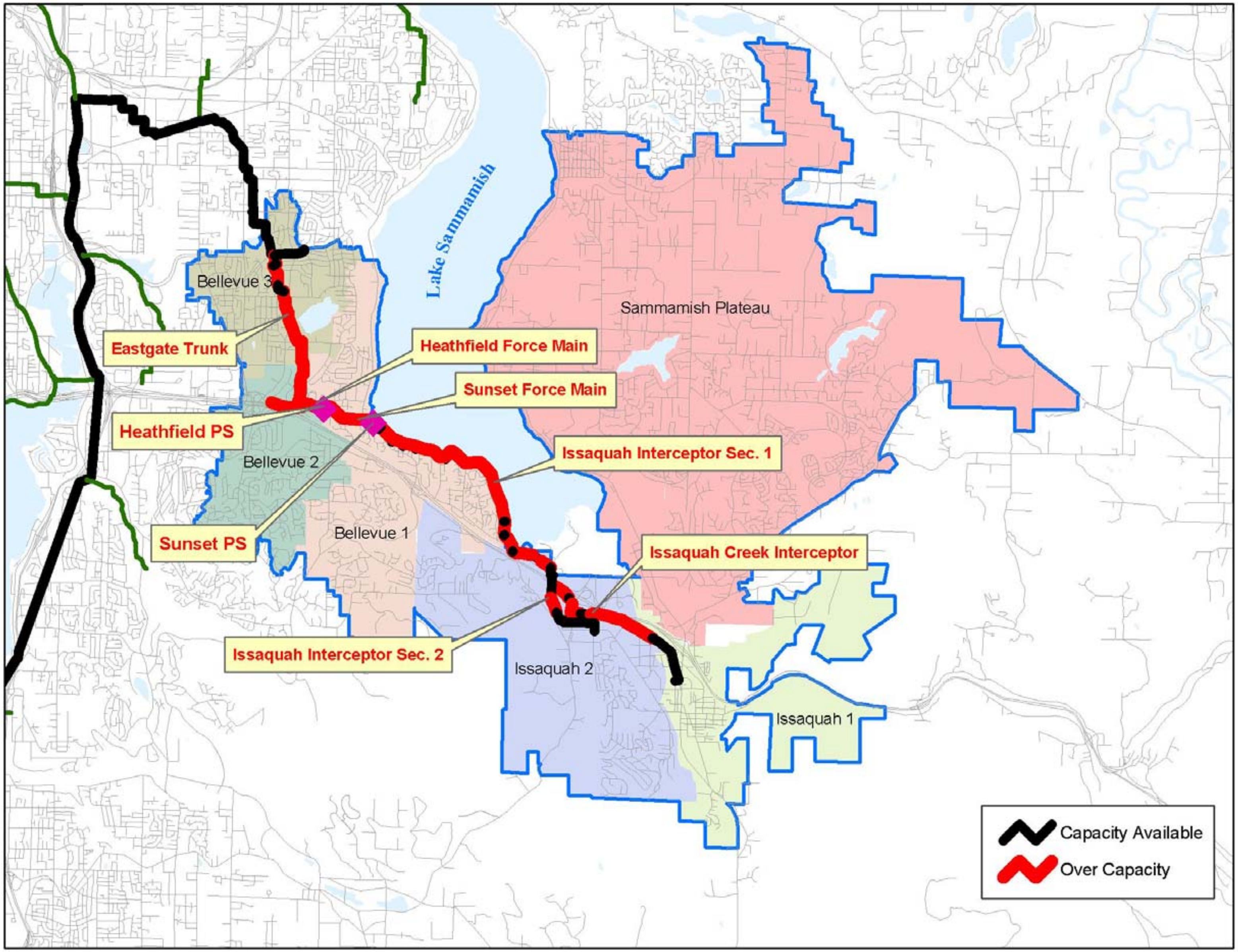
Lake Sammamish
Sammamish Plateau
Bellevue 3
Eastgate Trunk
Heathfield PS
Bellevue 2
Sunset PS
Bellevue 1
Issaquah 2
Issaquah 1
Capacity Available
Over Capacity

Year 2010



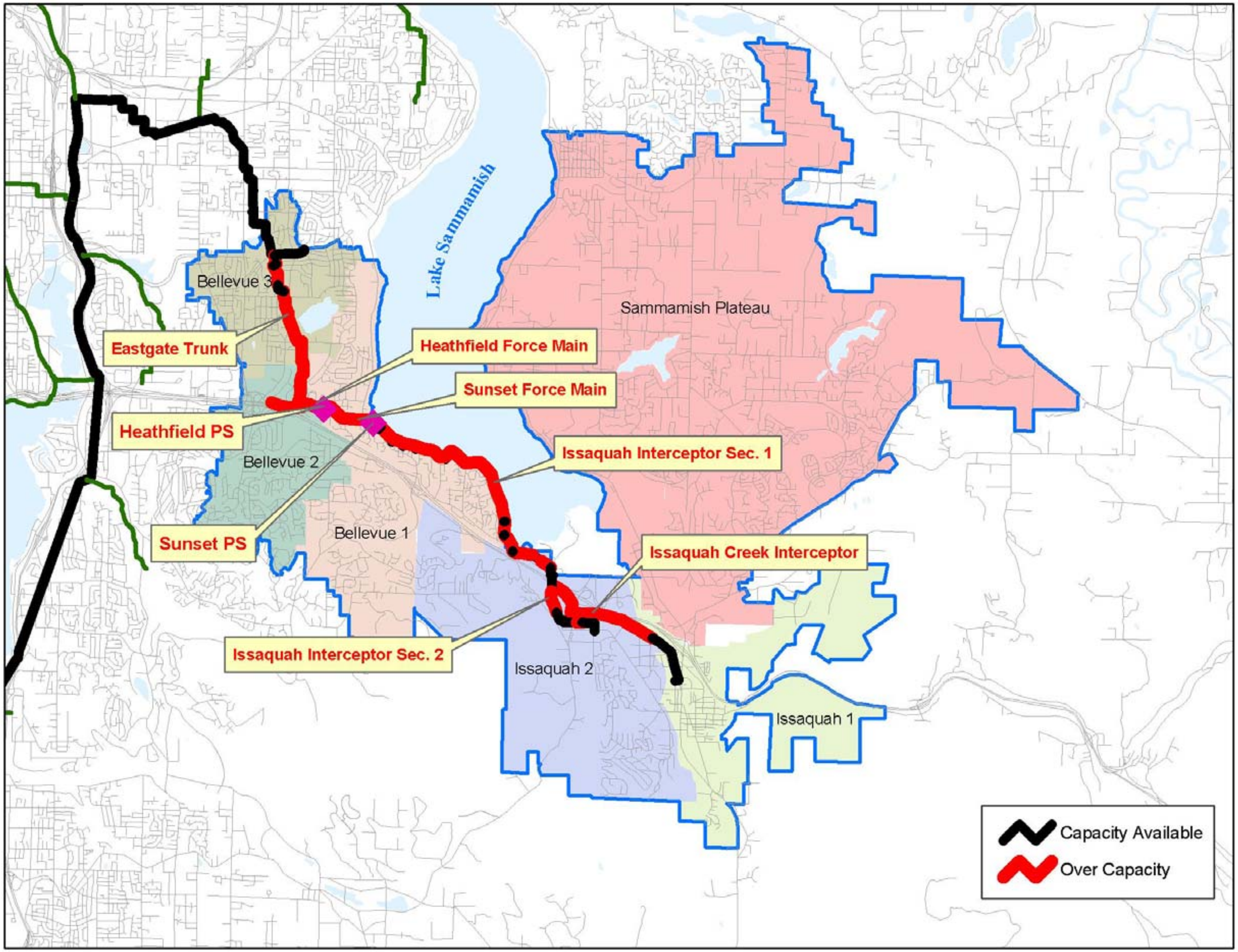
Lake Sammamish
Sammamish Plateau
Bellevue 3
Bellevue 2
Bellevue 1
Issaquah 2
Issaquah 1
Eastgate Trunk
Heathfield Force Main
Sunset Force Main
Heathfield PS
Issaquah Interceptor Sec. 1
Sunset PS
Issaquah Creek Interceptor
Capacity Available
Over Capacity

Year 2020



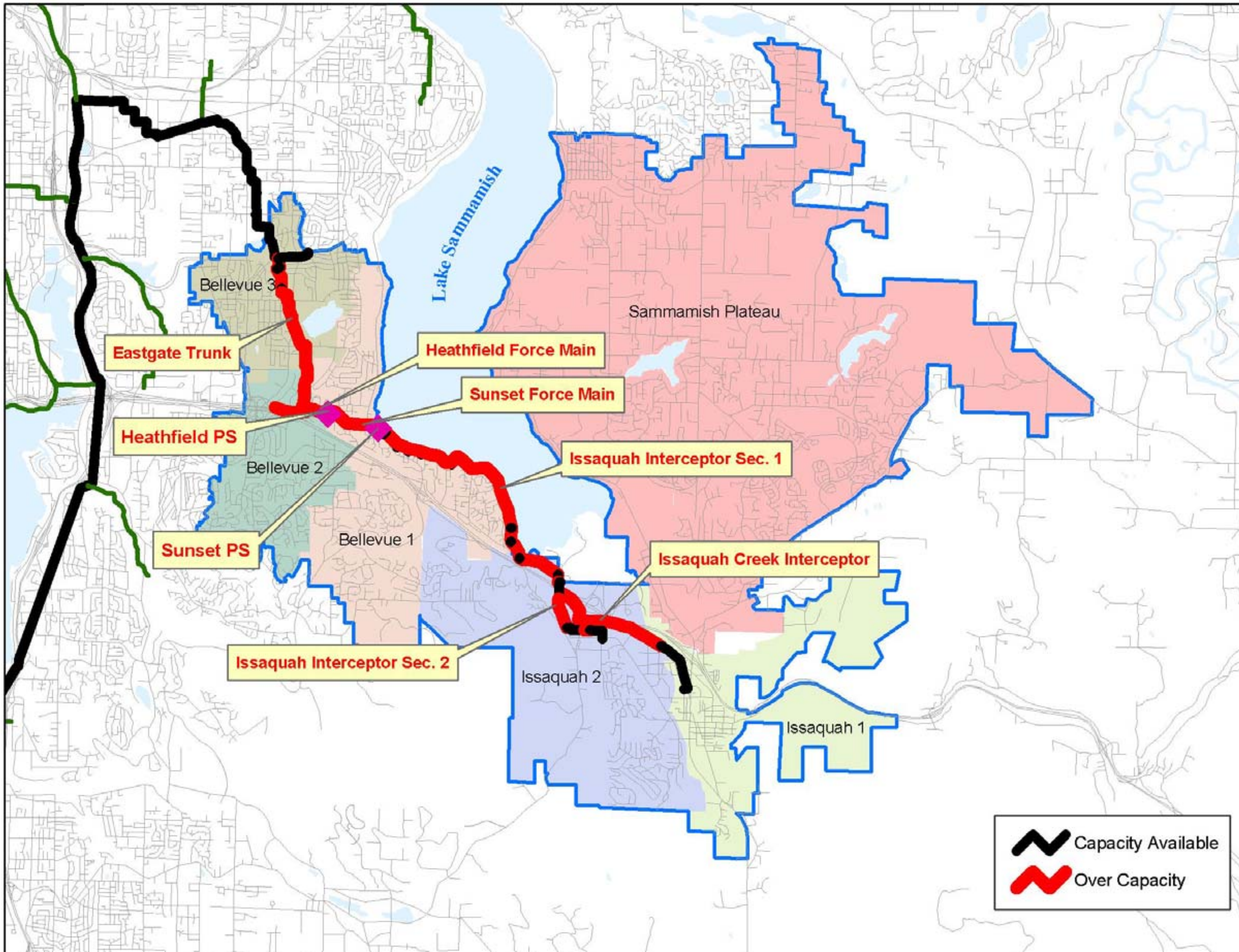
Lake Sammamish
Sammamish Plateau
Bellevue 3
Eastgate Trunk
Heathfield Force Main
Sunset Force Main
Heathfield PS
Bellevue 2
Issaquah Interceptor Sec. 1
Sunset PS
Bellevue 1
Issaquah Creek Interceptor
Issaquah Interceptor Sec. 2
Issaquah 2
Issaquah 1
Capacity Available
Over Capacity

Year 2030



Lake Sammamish
Sammamish Plateau
Bellevue 3
Bellevue 2
Bellevue 1
Issaquah 2
Issaquah 1
Eastgate Trunk
Heathfield Force Main
Sunset Force Main
Heathfield PS
Issaquah Interceptor Sec. 1
Sunset PS
Issaquah Creek Interceptor
Issaquah Interceptor Sec. 2
Capacity Available
Over Capacity

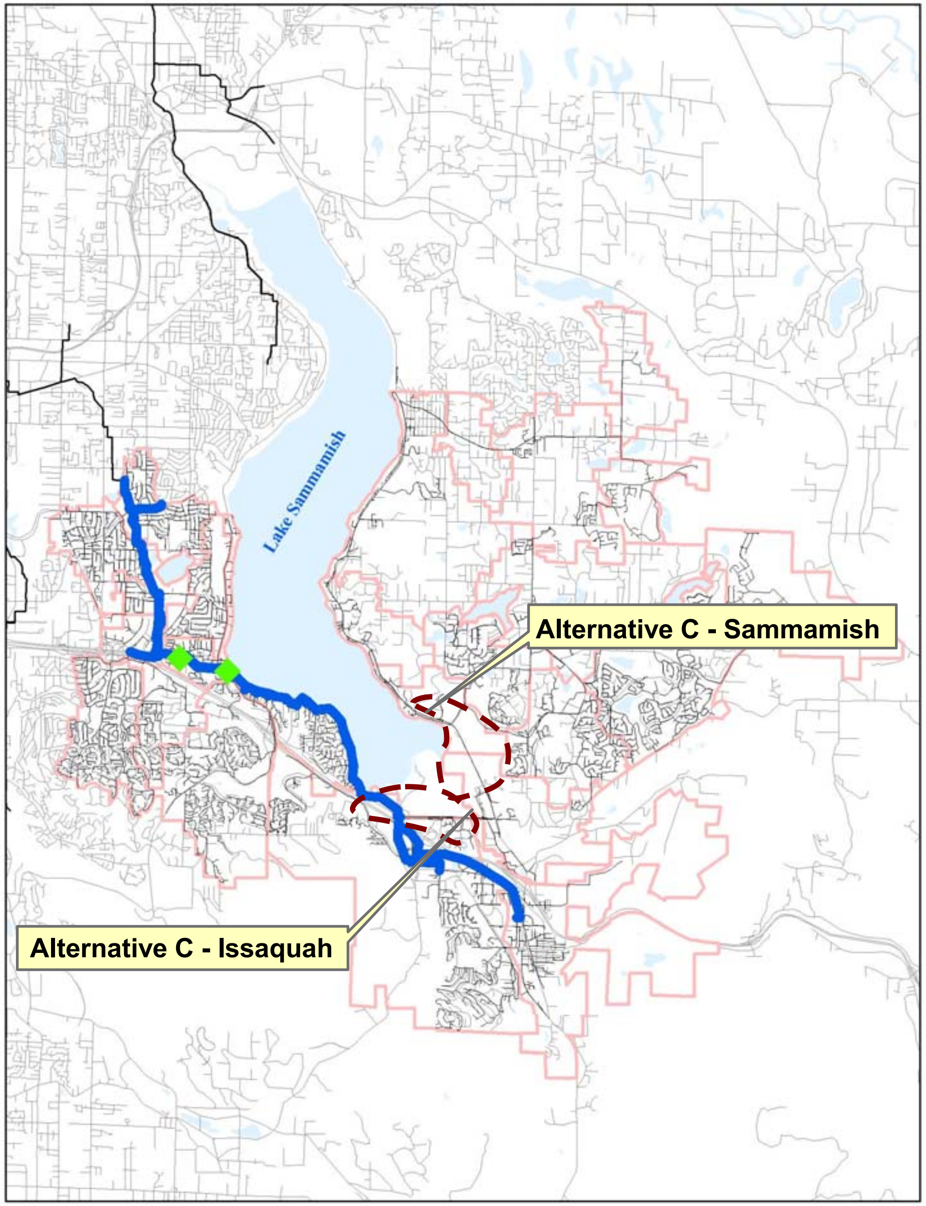
Year 2050



Lake Sammamish
Sammamish Plateau
Bellevue 3
Bellevue 2
Bellevue 1
Issaquah 2
Issaquah 1
Eastgate Trunk
Heathfield Force Main
Sunset Force Main
Heathfield PS
Issaquah Interceptor Sec. 1
Sunset PS
Issaquah Creek Interceptor
Issaquah Interceptor Sec. 2
Capacity Available
Over Capacity

Review Alternatives

Demand Management

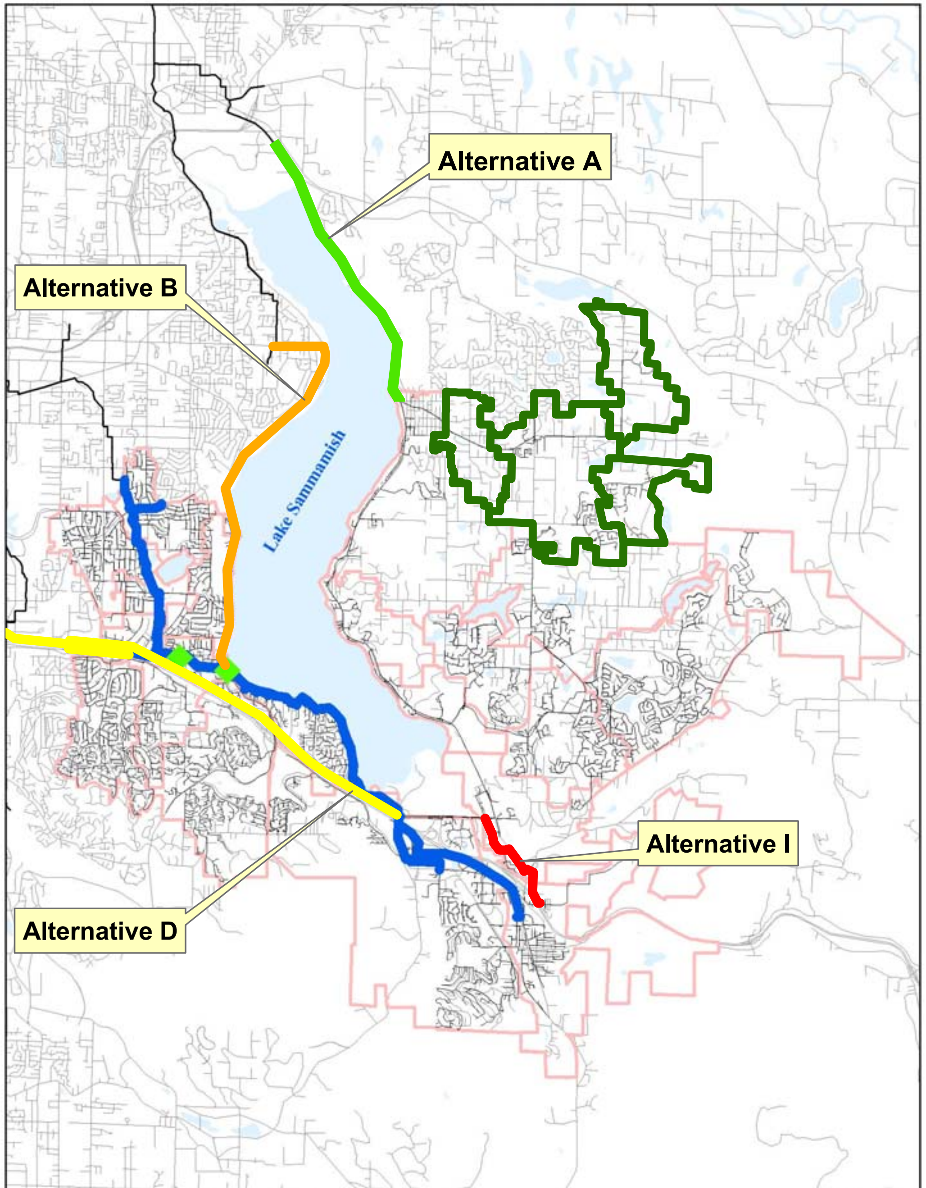


Alt C: Using storage tanks or tunnels to attenuate peak flows

Alt G: Targeted I/I reduction in coordination with the County's regional I/I program

Alt H: Reclaimed water production and discharge in the basin

Diversion



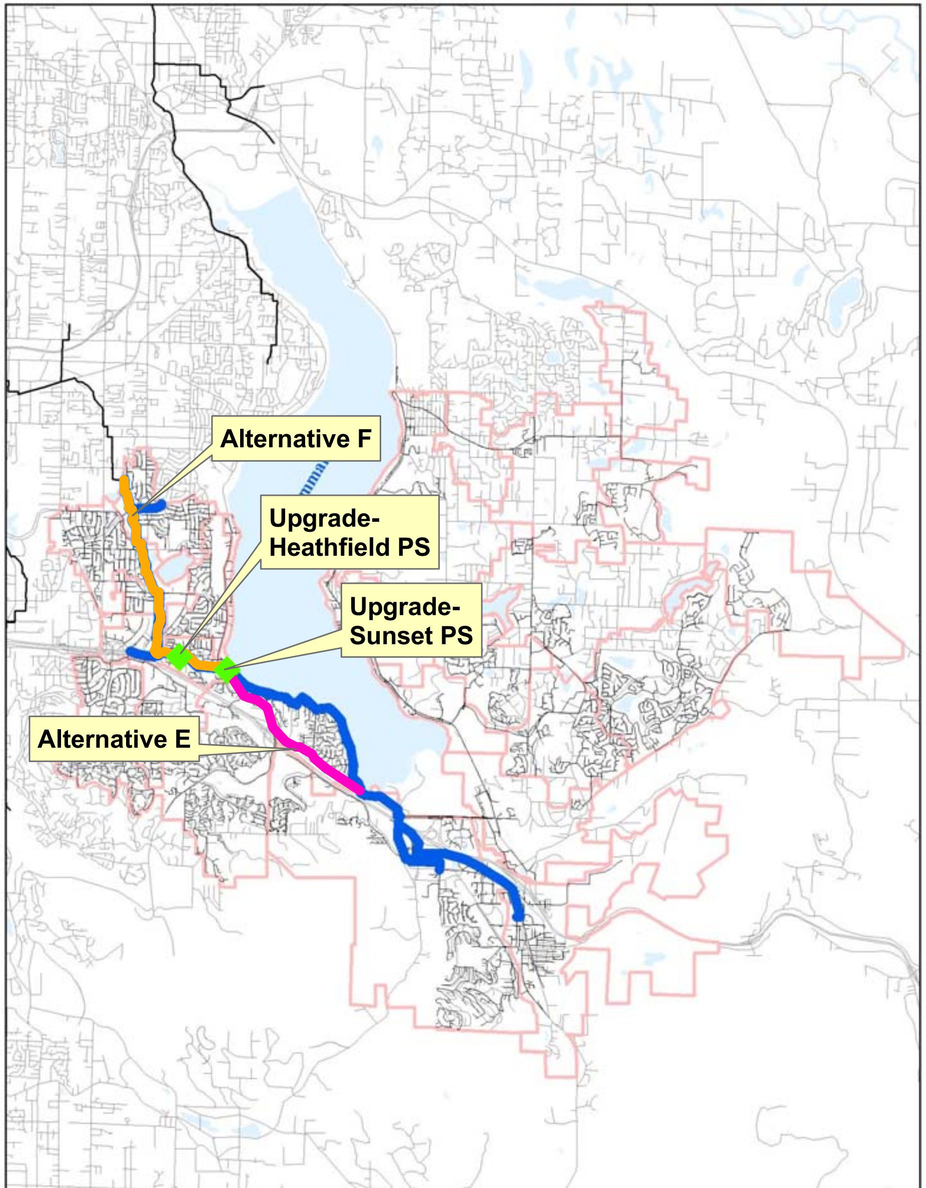
Alt A: Diverting a portion of Sammamish Plateau north to the NE Sammamish Interceptor

Alt B: Diverting wastewater away from Sunset PS, north along the west side of Lake Sammamish to the Lake Hills Trunk

Alt D: Divert flow along the I-90 right-of-way to the Eastside Interceptor

Alt I: Reroute the Issaquah Highlands drainage away from the Issaquah Creek Interceptor

Increase Capacity Conveyance

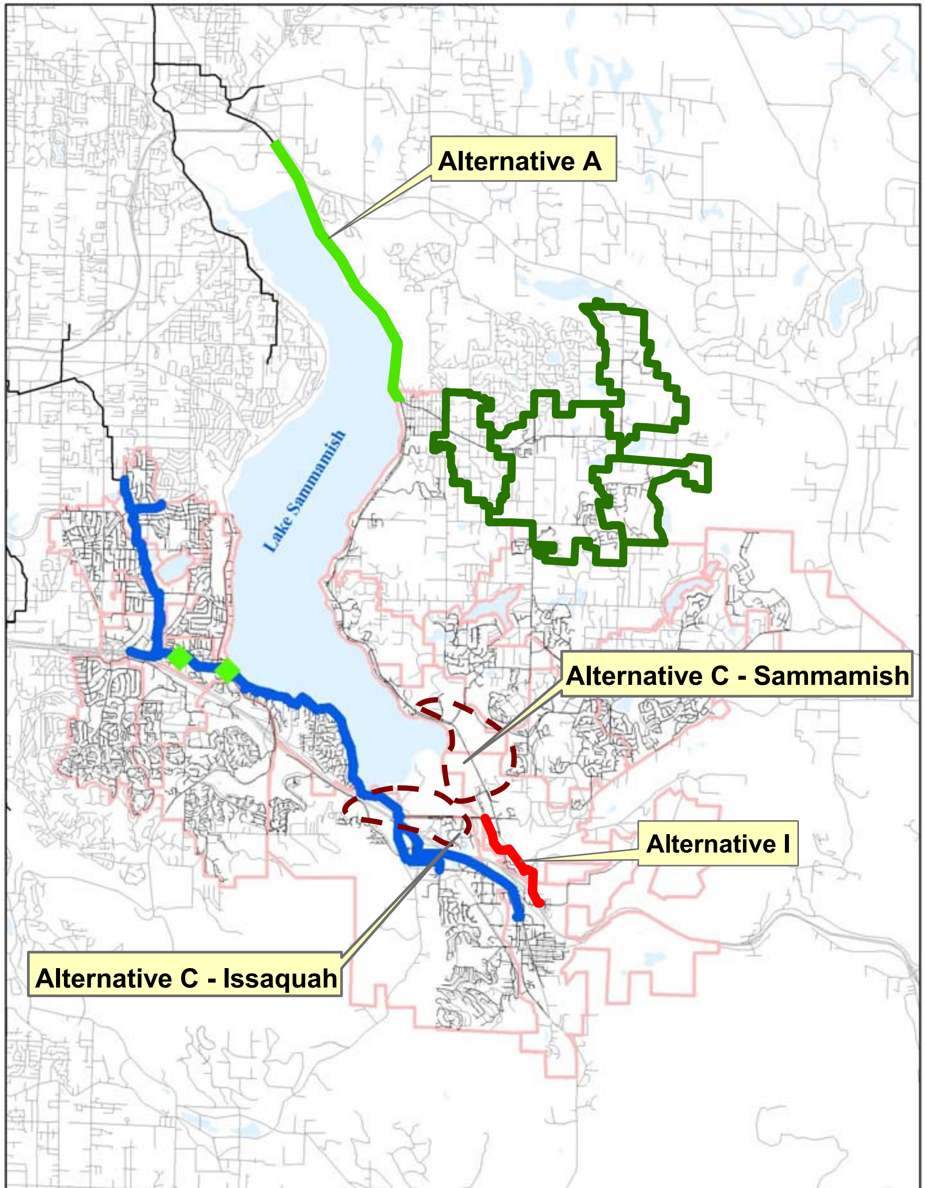


Alt E: Construct a land-based sewer to bypass Issaquah Interceptor Section 1 (lakeline)

Alt F: Increase capacity of Sunset and Heathfield Pump Stations and Eastgate Trunk

Package Alternatives

Package 1: Upstream Modifications to Limit Sunset PS and Heathfield PS Capacity



Alt I:

- On-line by 2010
- 7,200 lineal feet of 15-inch gravity sewer

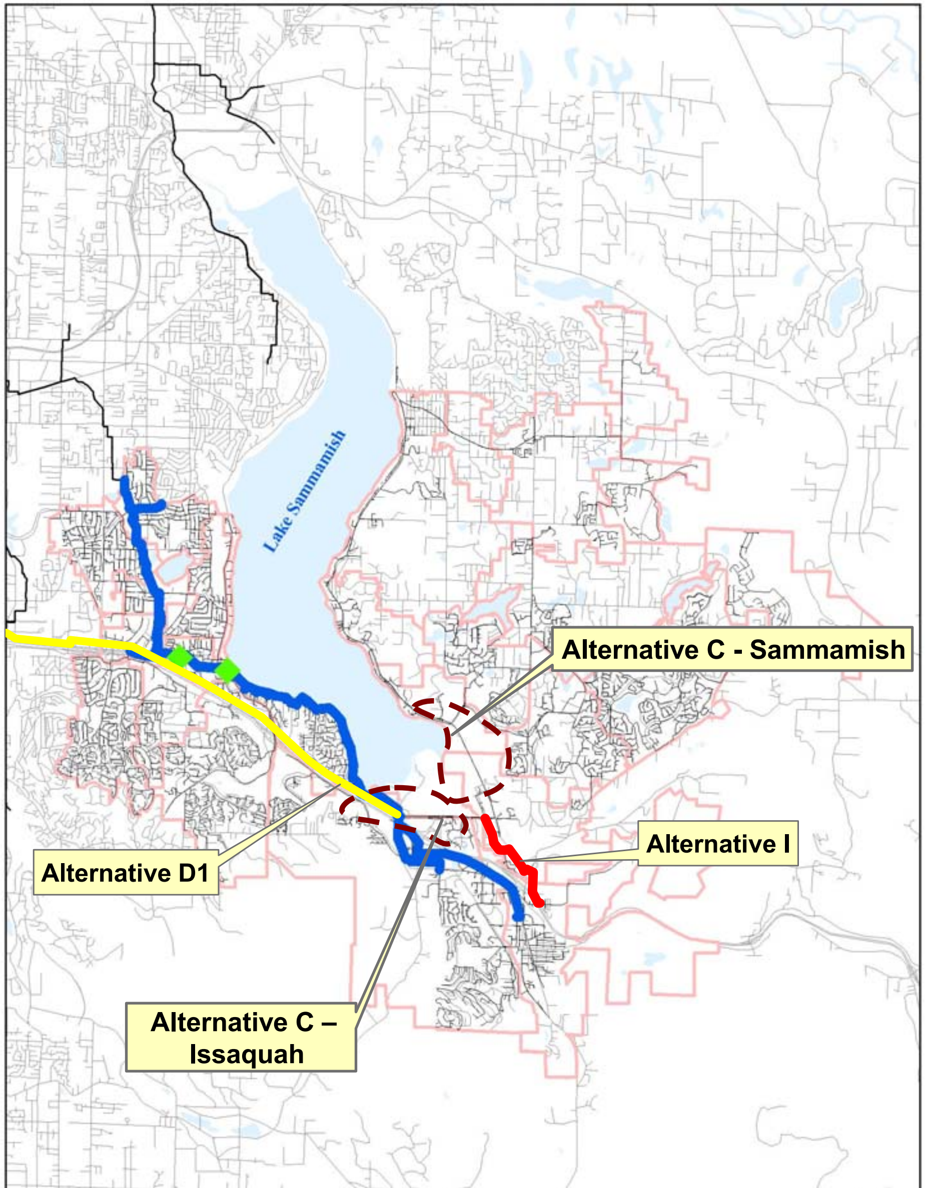
Alt A:

- On-line by 2010
- 18,500 lineal feet of 24-inch gravity sewer

Alt C:

- Issaquah storage on-line by 2010 and Sammamish Plateau storage on-line by 2020
- Issaquah and Sammamish Plateau storage both 1.5MG without I/I removal, and 1.5MG and 0.7MG with I/I removal, respectively.
    - 1.5MG Tunnel: 12 foot diameter, 1,800 lineal feet
    - 0.7MG Tunnel: 12 foot diameter, 850 lineal feet

Package 2: Diversion Using Parallel Transfer



Alt I:

- On-line by 2010
- 7,200 feet of 15-inch gravity sewer

Alt D1:

- On-line by 2010
- 17,500 feet of 18-inch force main
- Two 10 mgd pump stations in series, each with TDH 210 feet
- 12,000 feet of 24-inch microtunnel

Alt C:

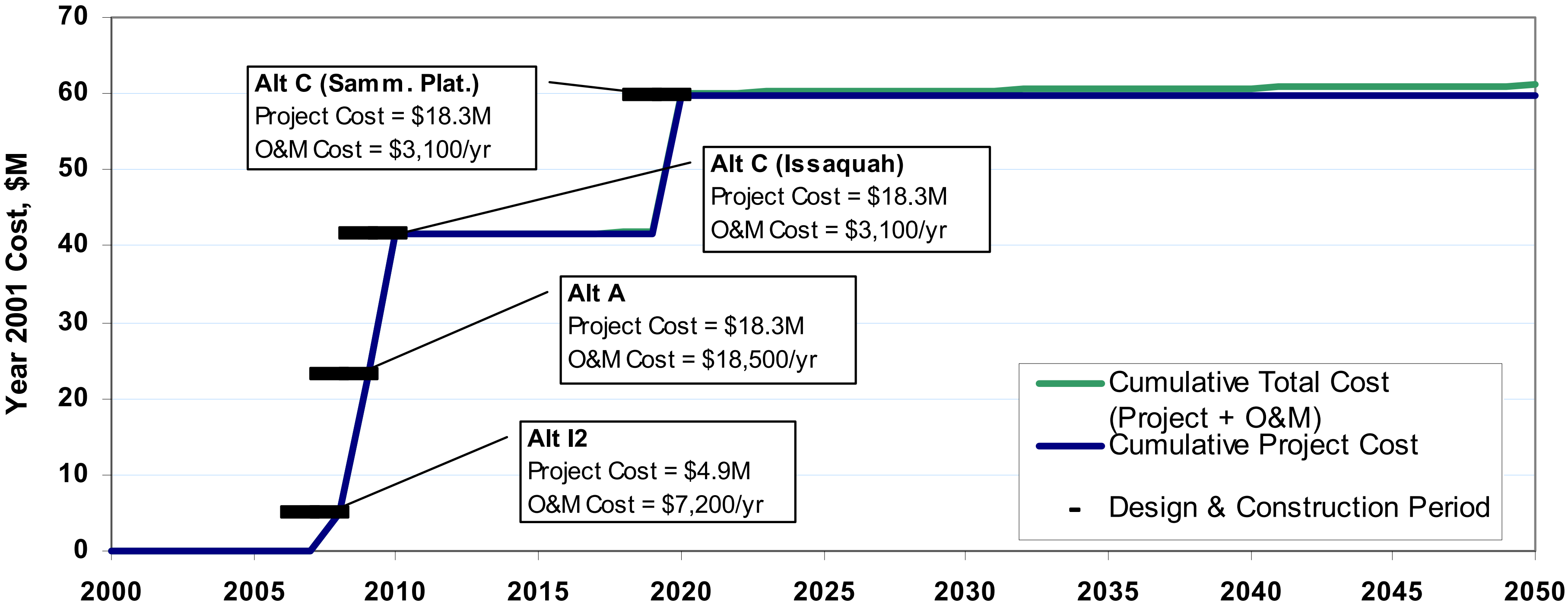
- Issaquah storage on-line by 2010 and Sammamish Plateau storage on-line by 2020
- Issaquah and Sammamish Plateau storage both 1.5MG without I/I removal, and 1.5MG and 0.7MG with I/I removal, respectively.
  - 1.5MG Tunnel: 12 foot diameter, 1,800 lineal feet
  - 0.7MG Tunnel: 12 foot diameter, 850 lineal feet

Project Schedule and Construction Cost Summary

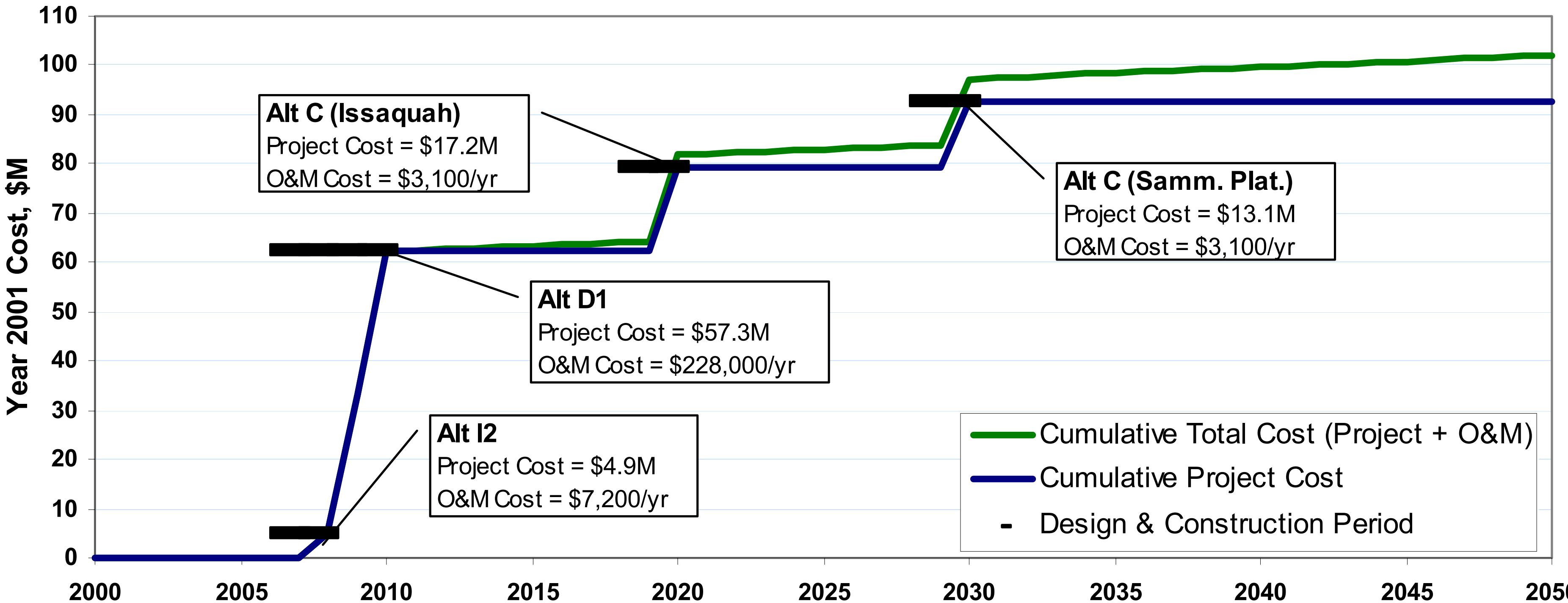
King County Department of Natural Resources and Parks

Conveyance System Improvements Project
South Sammamish Basin

Package 1: Project Schedule and Cost Summary



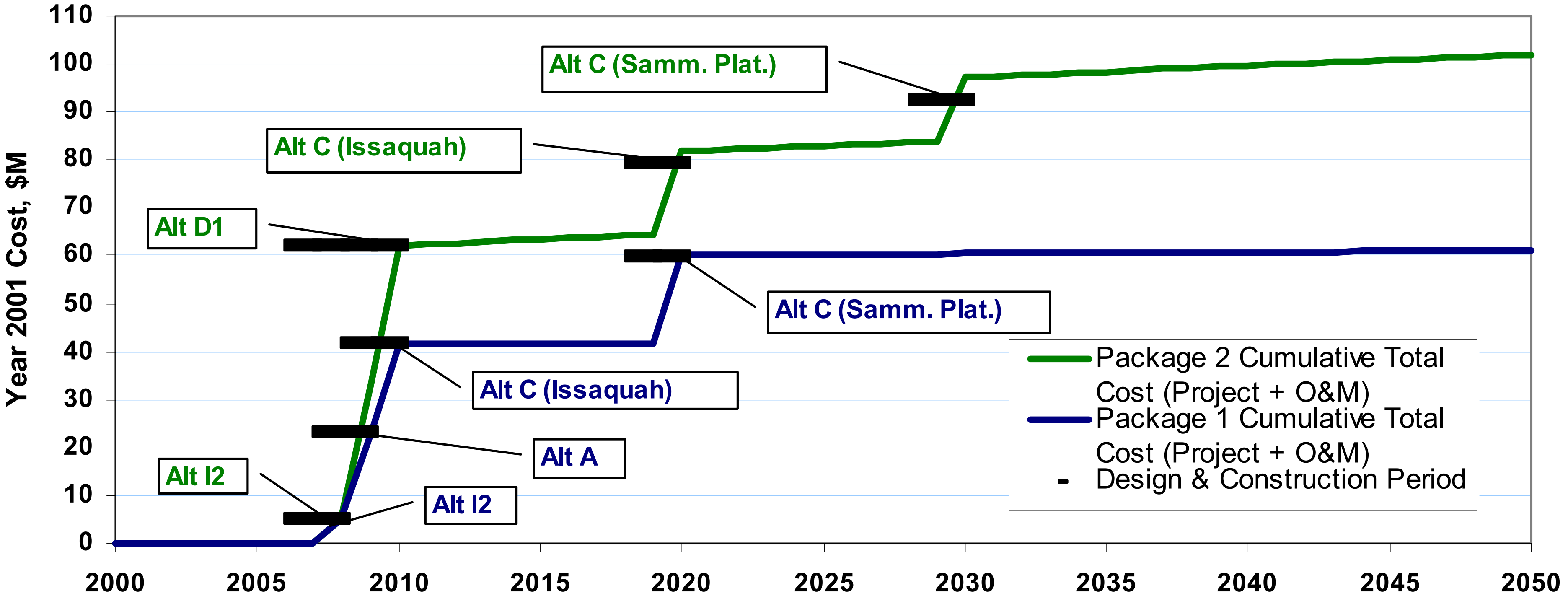
Package 2: Project Schedule and Cost Summary



King County Department of Natural Resources and Parks

Conveyance System Improvements Project
South Sammamish Basin

Package 1 and Package 2: Project Schedule and Cost Summary



Recommendation/Summary

Recommended Working Alternative Package

Package 1

King County's CSI Goals for South Sammamish Basin:

1. Meet SSO standard through 2050
2. Phased and adaptable wastewater management
3. Stage capital expenditures
4. Minimize operation and maintenance

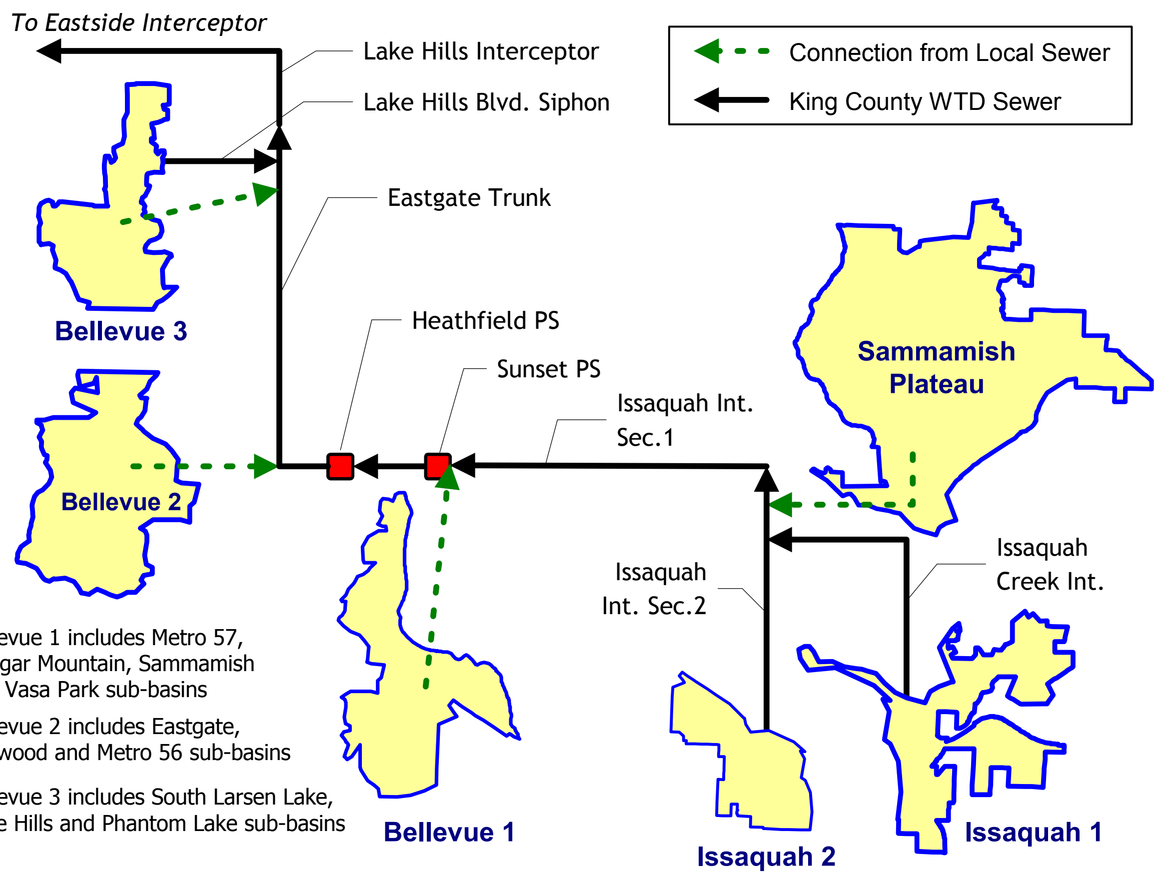
How Package 1 Meets King County's Goals:

1. All pipeline facilities will meet 20-year control and pump stations will meet 20-year control with minor station modification (+2 mgd).
2. Not a "large pipe solution". Diversion and storage alternatives allow phased construction and collaboration with ongoing King County projects.
3. 30% of total Package 1 project cost would be deferred until Year 2018.
4. No new pump stations. Gravity in/out storage facilities and gravity sewer pipe would require minimal O&M.

Questions and Comments?

Modeling Basin Flow Schematics

South Sammamish Basin Conveyance Facilities

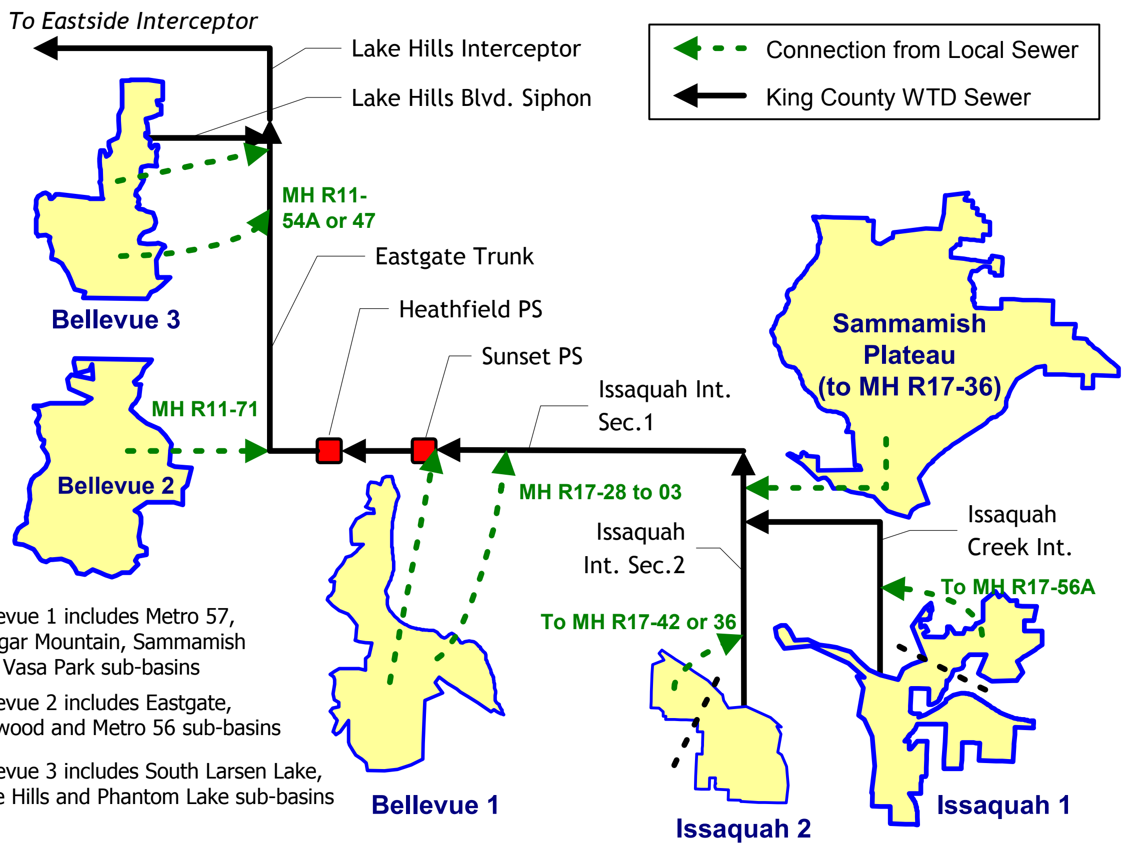


Bellevue 1 includes Metro 57, Cougar Mountain, Sammamish and Vasa Park sub-basins

Bellevue 2 includes Eastgate, Leawood and Metro 56 sub-basins

Bellevue 3 includes South Larsen Lake, Lake Hills and Phantom Lake sub-basins

Allocation of Modeling Basin Flow



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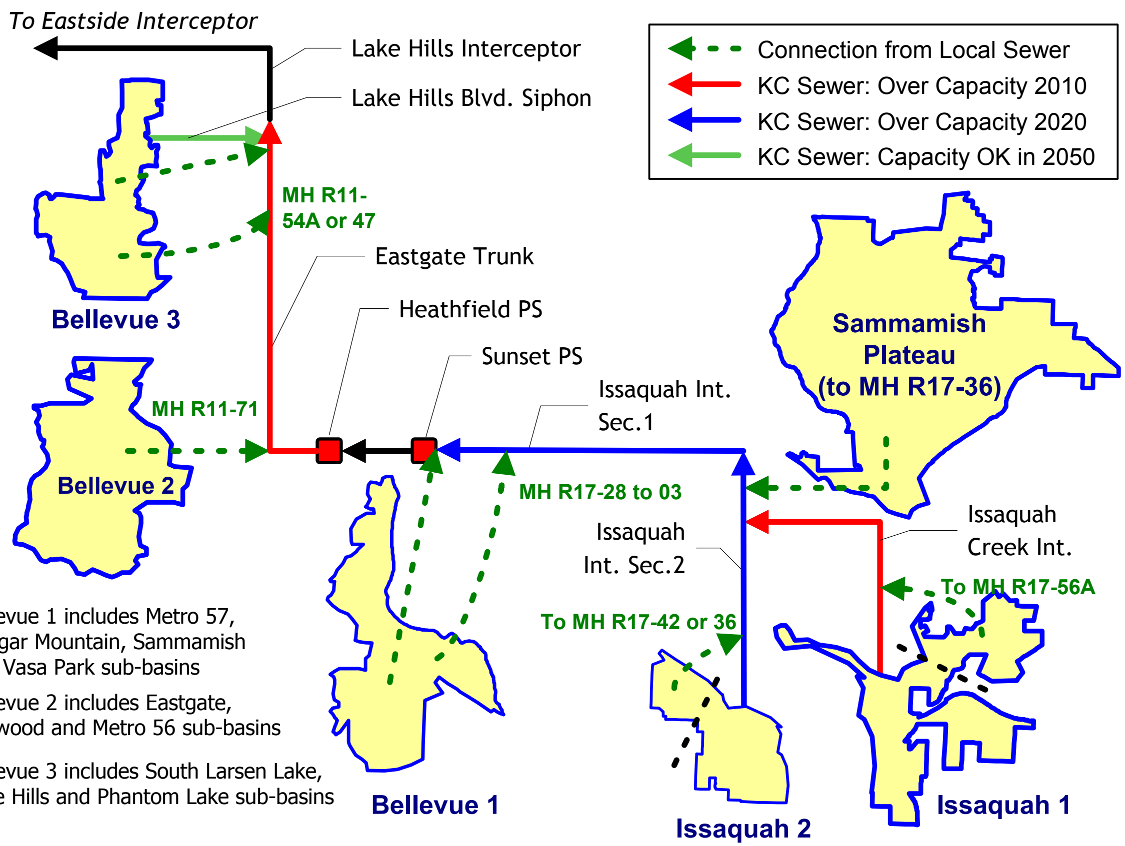
King County Department of Natural Resources and Parks

Conveyance System Improvements Project
South Sammamish Basin

Capacity Overview



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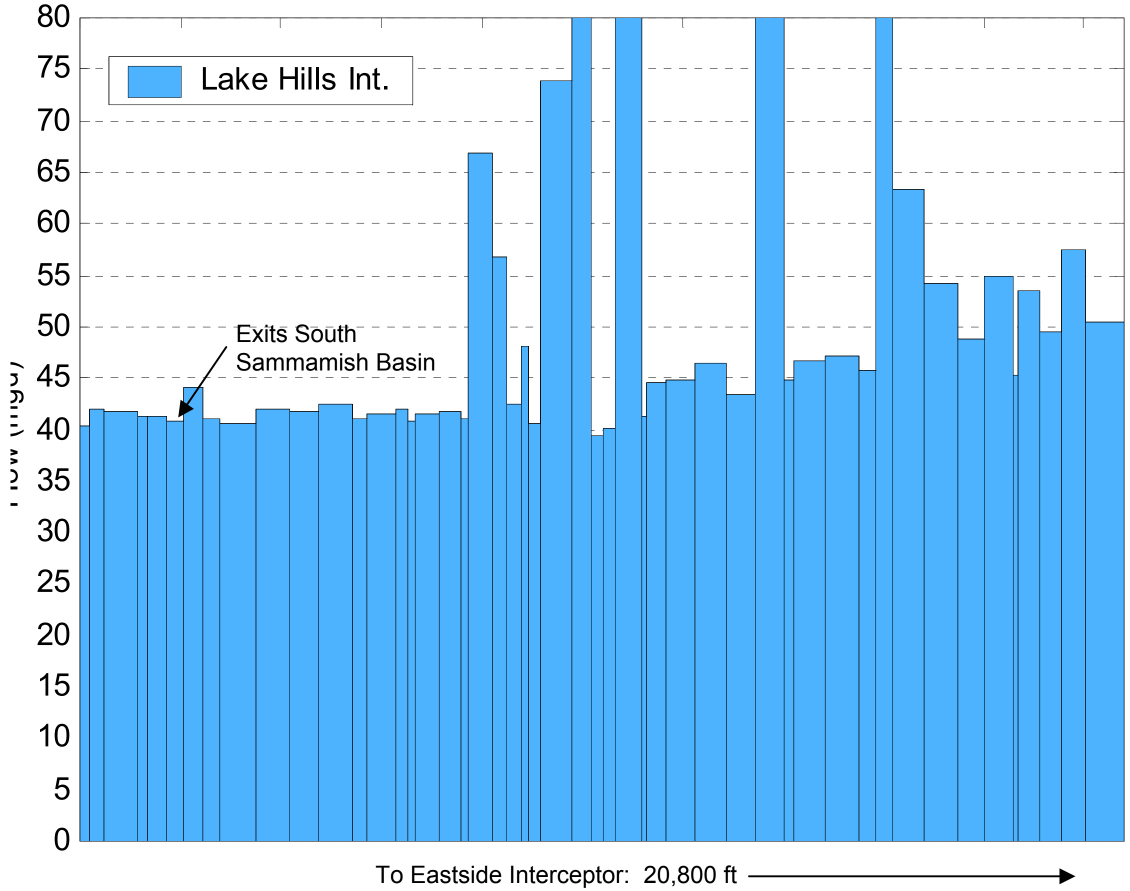
Bellevue 2 includes Eastgate, Leawood and Metro 56 sub-basins

Bellevue 3 includes South Larsen Lake, Lake Hills and Phantom Lake sub-basins

HDR
BROWN AND CALDWELL

Lake Hills Interceptor Capacity Overview



APPENDIX B: SAMMAMISH PLATEAU STORAGE OPTIONS

MEMORANDUM 14-17226.250\4

July 17, 2002

TO: BOB PETERSON, KING COUNTY WTD

FROM: TONY DUBIN, BROWN AND CALDWELL

SUBJECT: CSI SOUTH SAMMAMISH BASIN TASK 250
PEAK FLOW STORAGE ON THE SAMMAMISH PLATEAU

The working alternative for the CSI project's South Sammamish basin includes the construction of storage facilities on the Sammamish Plateau. The storage facilities would be designed to limit peak wet weather flows to the downstream capacity of the existing conveyance facilities, allowing the County to fully utilize existing facilities. This memorandum addresses the potential for storage at the Sammamish Plateau Water and Sewer District's (Sammamish Plateau WSD) control structure property located along NE 43rd Way (Figure 1).

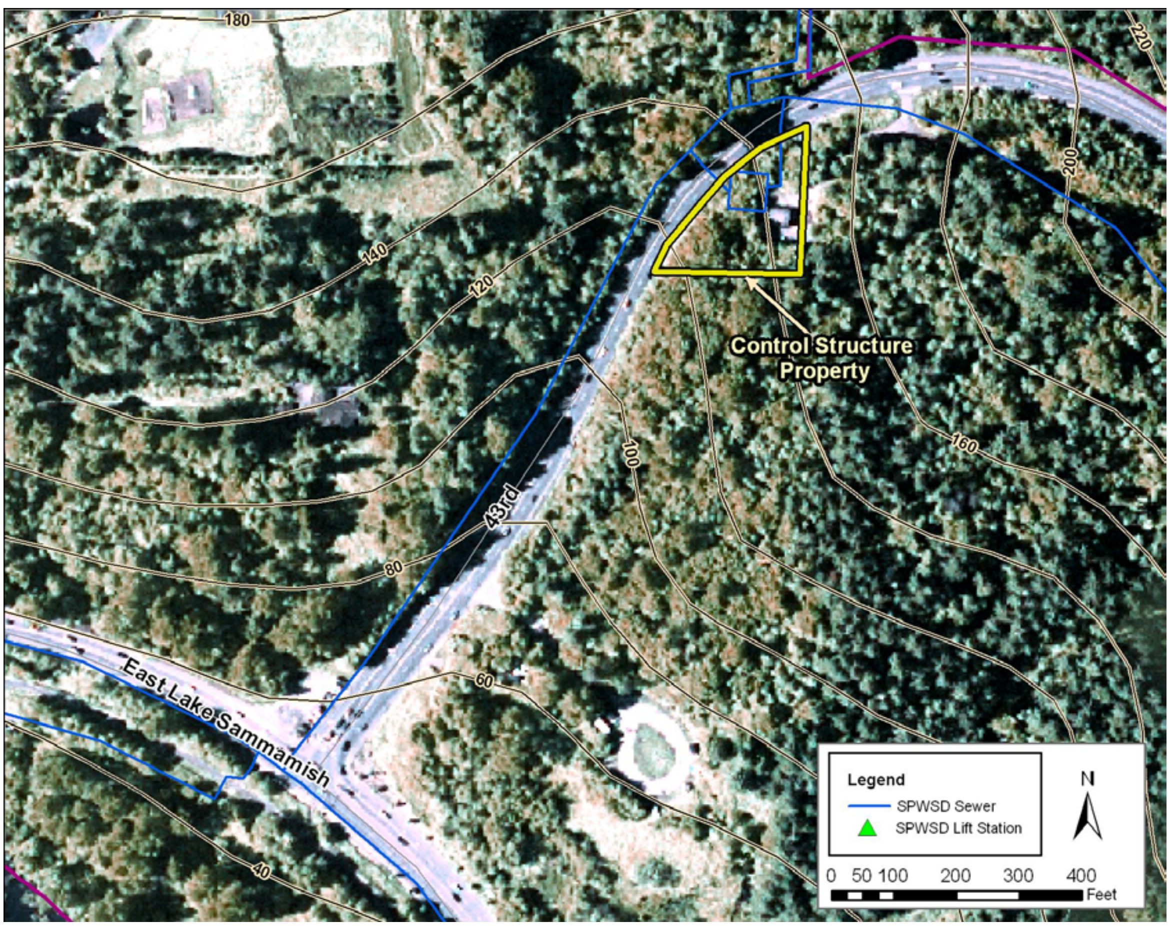


Figure 1. Location of Sammamish Plateau WSD hydraulic control structure.

The effectiveness of storage at the Sammamish Plateau WSD control structure property depends of the following factors:

1. **Peak Flow Rate.** The flow generated upstream of the property must be high enough that flow detention would significantly reduce Issaquah Interceptor flow.
2. **Property Size and Storage Volume.** The property must accommodate a large enough storage volume to substantially reduce flows. The working alternative calls for approximately 1 million gallons of storage in the Sammamish Plateau WSD service area.
3. **System Hydraulics.** Storage on the Sammamish Plateau would be most effective if aligned for gravity in/out operation. The outlet structure could be operated to limit flow to the available downstream capacity.
4. **Construction Factors.** The proposed site is part way up a large hill that links the Sammamish Plateau to Lake Sammamish.

Peak Flow Rate

Approximately half of the Sammamish Plateau WSD's existing sewer system drains to the control structure on NE 43rd Way[1]. The alignment of the District's sewer basins shows that a similar fraction of the District will continue past this location in the future after the available land has been developed. Table 1 lists the projected base flow and peak 20-year flow past the control structure in 2005 and 2050. The projections are based on the County's base flow and I/I projections (see Table 1 of the Task 240 report) and the Sammamish Plateau WSD estimate of the fraction of customers and sewered area upstream of the control structure. Figure shows the areas draining past the control structure. The flow projections demonstrate there is enough flow at the control structure that detainment during a large storm event would help preserve capacity in the downstream facilities, some of which will reach their capacity in the next 10 years.

Table 1. Flow to the Sammamish Plateau Control Structure on NE 43rd Way

	2005	2050
Sammamish Plateau Flow		
Base Flow (mgd)	2.2 mgd	4.1 mgd
Peak 20-year Flow (mgd)	9.3 mgd	22.4 mgd
Flow To NE 43rd Way Control Structure		
Fraction of Total Customers	61%	51%
Base Flow (mgd)	1.36 mgd	2.08 mgd
Fraction of Sewered Area	50%	50%
Peak 20-year Flow (mgd)	**4.8 mgd**	**11.2 mgd**

[1] The North Sunny Hills, Trossachs, Laughing Jacobs, Yellow Lake and South Pine Lake basins account for about half of the Sammamish Plateau WSD service area and estimated sewered area. The South Pine Lake discharges to NE 43rd Way just below the diversion to the control structure. If a storage facility replaced the control structure, the South Pine Lake discharge could be rerouted to through the storage facility.

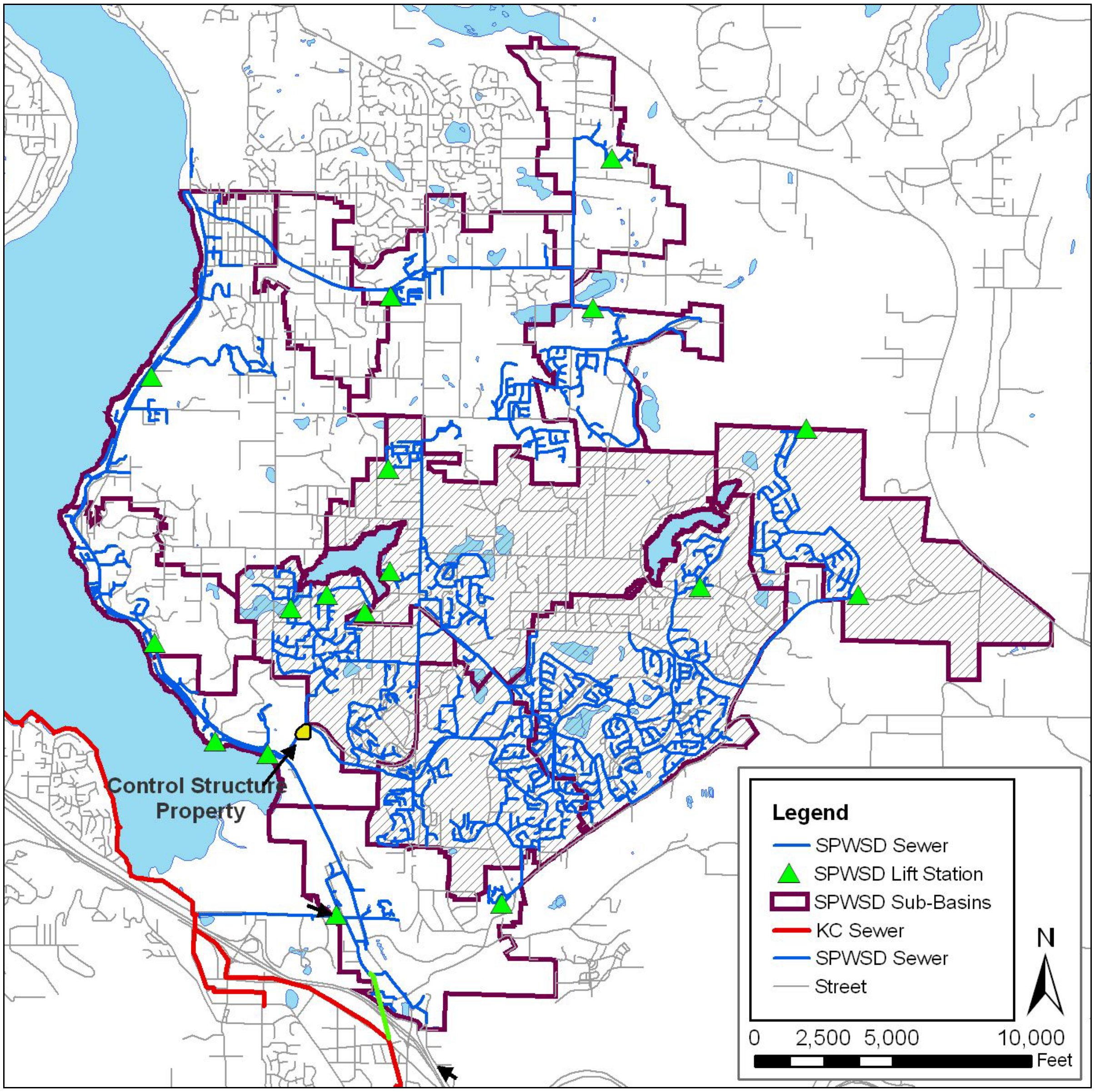


Figure 2. Sammamish Plateau WSD Service Areas Tributary to Control Structure

Property Size and Storage Volume

The Sammamish Plateau WSD property with the control structure is located half way up the hillside between Lake Sammamish and the top of the Sammamish Plateau. The property slopes downward from east to west and is 0.79 acres in extent. It is surrounded by large wooded parcels on the hill slope (see Figure 1). Because the elevation of the property is about 80 feet higher than the East Lake Sammamish Parkway and other conveyance lines, the storage unit could be buried and allow gravity in/gravity out flow.

The property is large enough to accommodate a range of storage volumes. For example, a 50-foot diameter, 30-foot deep tank would provide 440,000 gallons of storage. Linking the tank to 8-foot diameter, 1000-foot long storage tunnel to East Lake Sammamish Parkway would increase the storage volume to more than 800,000 gallons. With a 10-foot diameter tunnel, the total storage would be 1,000,000 gallons. Figure 3 shows various size tank diameters relative to the boundaries of the property.

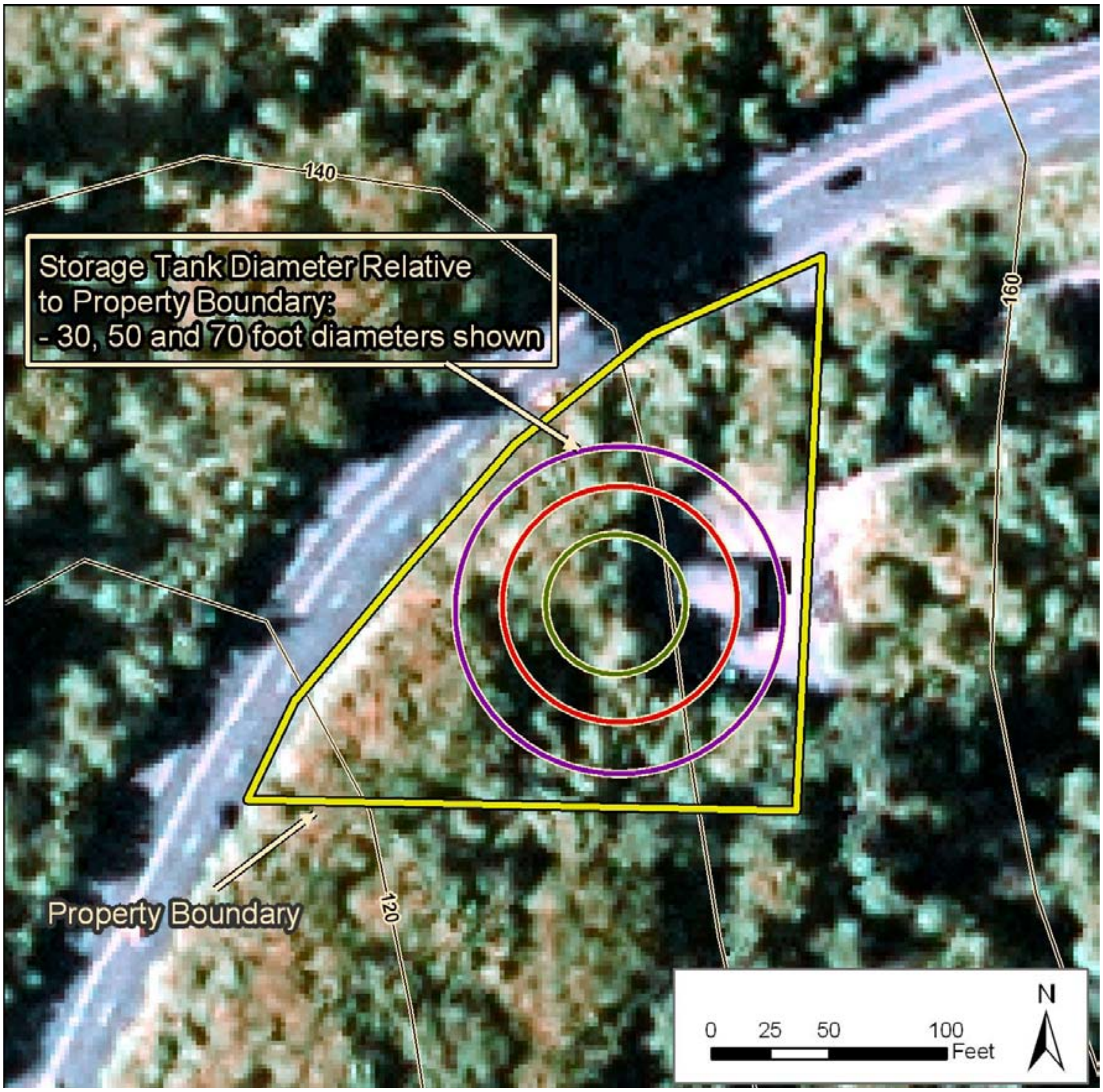


Figure 3. Control Structure Property with Tank Footprints

<u>System Hydraulics</u>
The placement of a tank as shown in Figure 3 would allow gravity drainage down the hillside to existing collection system pipes. There is enough head to drive a pressure gravity pipe to the piping that connects with the County's system as follows:

- If the King County Extension pipe is routed across Lake Sammamish State Park, the wastewater discharged from the storage tank would flow to the extension sewer on East Lake Sammamish Parkway at the state park. The difference in elevation approximately 60 to 70 feet[2] over a distance of 2,100 feet.
- If the SE 56th Street alignment is maintained, the tank discharge would flow by gravity an expanded SE 56th Street pump station. The elevation difference is 50 to 60 feet over a distance of 7,200 feet.

In either case, there is enough head to drive pressurized flow. The exact size of the pipe will depend on the alignment and how the system is operated. The tank discharge pipe could be used for conveyance only or as part of a larger detention system. During high flows, the tight line pipe could back up along East Lake Sammamish Parkway and tunnel storage on the flat section of the parkway would become dead storage. Therefore, tunnel storage on the hillside will be more effective than tunnel storage along East Lake Sammamish Parkway.

If the storage tank has a telemetry connection to the Issaquah Interceptor Section 1, an automated gate could regulate storage and limit downstream flow to prevent overflows. The pipe sizing should be part of an integrated hydraulic analysis of the storage tank and other conveyance facilities in the area.

Construction Factors

The control structure property is located in a steep slope area, as identified in the King County Sensitive Area Ordinance coverage. The property slopes an average of six percent from the northeast to the southwest. The property is partially cleared of trees and there are existing wastewater conveyance facilities that would be removed if a storage tank were constructed (see Figure 1).

Summary

The property containing the Sammamish Plateau WSD control structure is large enough and receives enough flow that a storage tank or storage tank and tunnel system would provide a regional conveyance benefit. Most if not all of the Sammamish Plateau storage volume specified in the CSI South Sammamish basin working alternative could be accommodated at this site and in an adjacent tunnel. The local topography would allow for gravity in and gravity out flow, reducing operating cost and potentially reducing the amount of tank cleaning and other maintenance needs. The steep slopes and traffic on NE 43rd Way could provide some construction challenges that must be addressed.

[2] Assumes a storage tank discharge elevation of 100 feet above mean sea level (Metro datum).

APPENDIX C: SENSITIVITY ANALYSIS

MEMORANDUM 14-17226.250/4

April 23, 2002

TO: BOB PETERSON, KING COUNTY WTD
JIM PETERSON, HDR

FROM: TONY DUBIN, BROWN AND CALDWELL

SUBJECT: CSI SOUTH SAMMAMISH BASIN: POTENTIAL IMPACTS OF UNCERTAINTY IN FUTURE FLOW PROJECTIONS ON WASTEWATER CONVEYANCE IMPROVEMENT PLANNING

Background
During the Conveyance System Improvement Project South Sammamish Basin decision workshop on February 11, 2002, the King County staff in attendance reached a consensus to a specific working alternative for system improvements. The working alternative includes a combination of flow diversion on the Sammamish Plateau and Issaquah Highlands, minor pump station improvements, and storage in Issaquah and Sammamish Plateau. The construction of these facility improvements will be staged over two decades.

Purpose of the Sensitivity Analysis
The timing of conveyance upgrades is linked to the County's future wet weather peak flow predictions. These predictions are themselves based on model calibration to collected flow data, assumptions about future I/I rates, sewer degradation impacts, and growth forecasts. Through continued flow monitoring and refinements to the flow and sewered population projections, the County will be able to narrow the uncertainty about the timing and size of future conveyance facilities.

The alternative packages presented at the South Sammamish Basin decision workshop attempted to balance the short-term need for improved conveyance and the longer term uncertainty regarding growth and peak wet weather flow. This sensitivity analysis examines several "What If" scenarios for future flows and determines if the working alternative can be adapted to each of these possibilities. Once the working alternatives flexibility is established, the County can move forward with a plan that will maintain its SSO standard, while avoiding large capital expenditure on facilities that in the future may be deemed too large or not large enough.

Sensitivity Analysis Method
Most of the uncertainty in the future flow predictions is due to the amount of developed and unsewered and undeveloped sewerable land in Issaquah and the Sammamish Plateau. The forecasts reported in the Task 210 report show the sewered area and the population served by a sanitary sewer will double by 2050 in Issaquah. In Sammamish Plateau, this report forecasts the sewered population will more than double, and the sewered area will increase by more than two

and a half times. Along with development comes uncertainty over when the sewers will come online and how much I/I will these new systems admit. Four scenarios have been developed to gauge the impact of development on future wet weather flows and the South Sammamish Basin working alternative (Table 1). These scenarios are designed to enclose the likely range of future flow conditions:

Table 1. Future Growth and Flow Scenarios for Issaquah and Sammamish Plateau

Scenario	Issaquah			Sammamish Plateau		
	Sewered Population Growth	Existing & Future I/I Rate	Fully Sewered	Sewered Population Growth	Existing & Future I/I Rate	Fully Sewered
1. High Issaquah & Sam Plateau	+20%	+33%	2010	+20%	+33%	2010
2. High Issaquah	+20%	+33%	2010	-	-	2020
3. High Sammamish Plateau	-	-	2020	+20%	+33%	2010
4. Low Issaquah & Sam Plat	-20	-33%	2030	-20	-33%	2030

The scenarios examined focus on Issaquah and the Sammamish Plateau sections of the South Sammamish Basin, not Bellevue. The reasons for this are twofold: (1) the Bellevue basins are almost entirely built out, and (2) the major conveyance bottlenecks occur upstream of Bellevue. The new facilities proposed for the South Sammamish Basin will limit the amount of flow reaching the Eastgate Trunk (in Bellevue) to within its conveyance capacity.

Sensitivity Analysis Results
Figure 1 shows the projected 20-year peak hour flow by decade for the area tributary to the Sunset Pump Station (i.e. Issaquah, Sammamish Plateau, Bellevue 1 basins) for the baseline condition reported in Task 240 and for each of the scenarios described above. Figure 2 shows the 20-year peak flow for the entire South Sammamish Basin assuming current management of flows (i.e. no transfers to the north)

Figures 1 and 2 demonstrate a range of probable flows. Through a combination of rapid growth, sewer expansion and higher I/I rates, Scenario 1 predicts as much as 13 mgd more than the Task 240 flow projections in 2010 for the peak 20-year flow, though the difference between the two narrows later in the planning window. Scenario 4, which reflects reduced and delayed development, predicts as much as 10 mgd less than the baseline flow projection for the peak 20-year flow in 2020. While Scenarios 1 and 4 represent an outer range of future flows, the future development/flow condition will probably be closer to that presented in the Task 240 report, because the Task 240 projections are based on the best available growth forecasts from the County and local agencies, and the best available flow data.

The key issue for analyzing these scenarios is how they affect when additional capacity will be needed. Table 2 lists the additional capacity schedule for the County's conveyance facilities in the basin. (This table is an expanded version of Table 21 in the Task 240 report.)

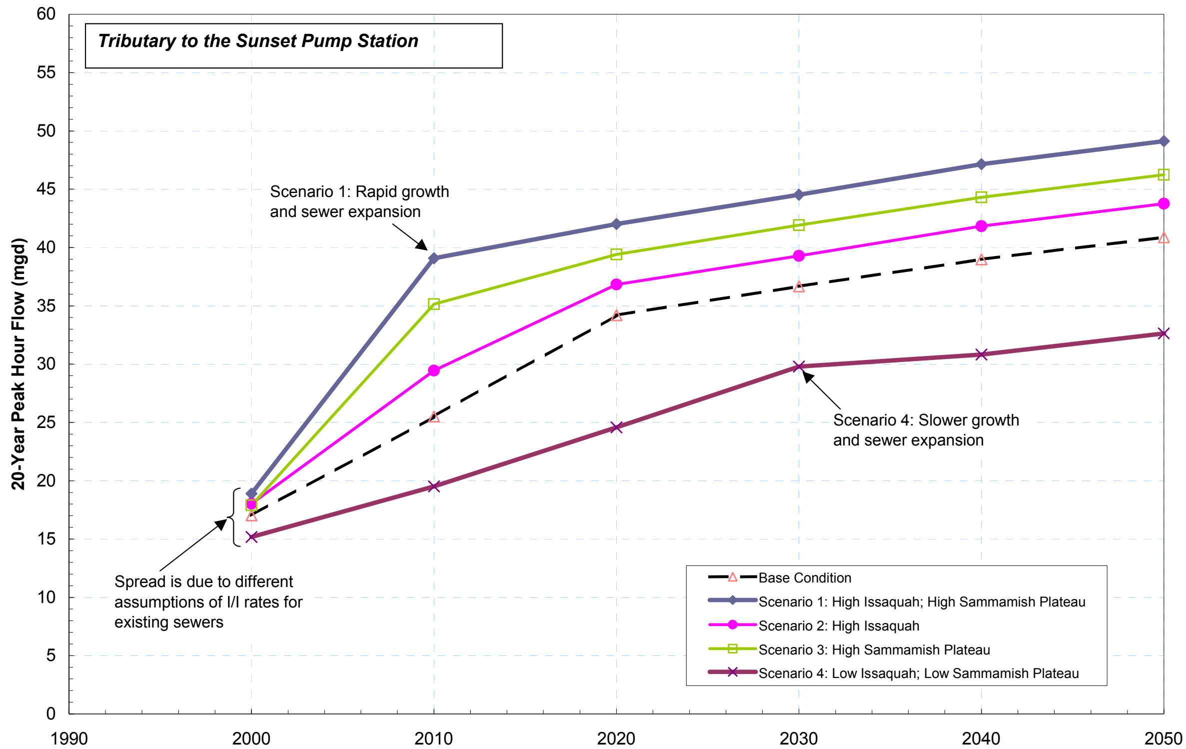


Figure 1. Range of Flows to Sunset Pump Station

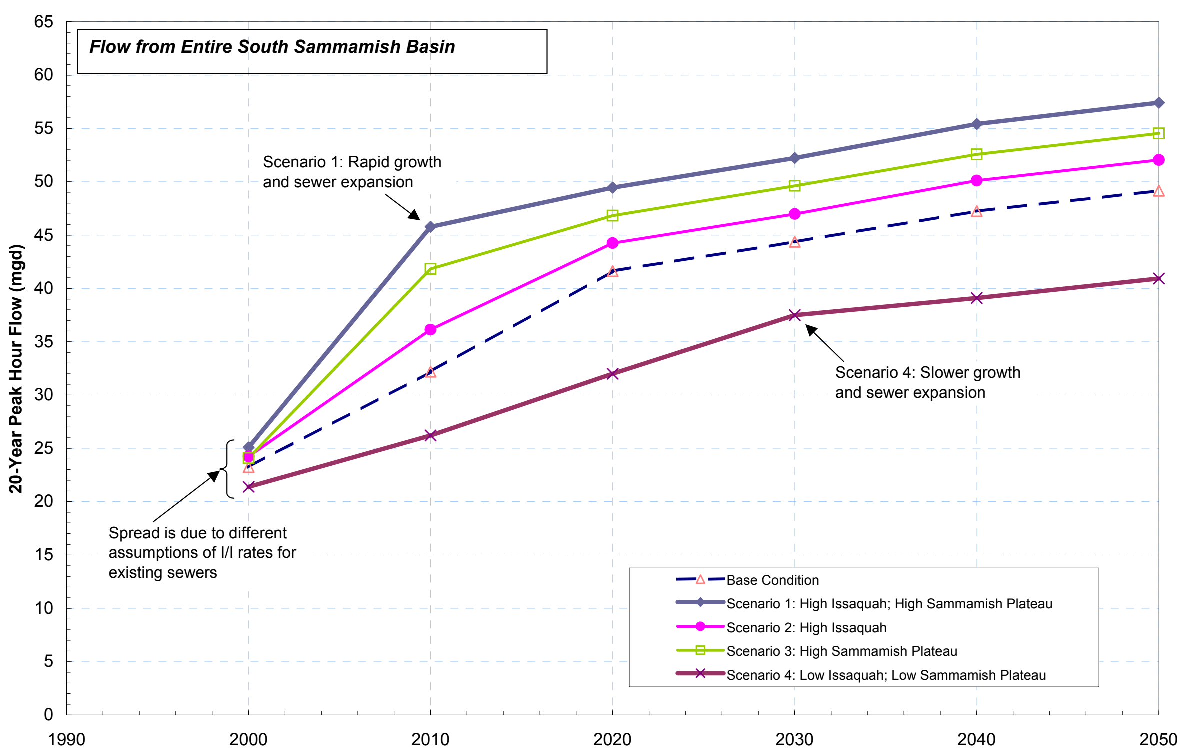


Figure 2. Range of Flows in the South Sammamish Basin

Table 2. Schedule of Facilities Reaching Capacity

Conveyance Facility	Scenario	When Additional Capacity Needed	Additional Capacity Needed in 2010/ 2020[A]	Additional Capacity Needed in 2050 [A]
Issaquah Creek Int.	Scenario 1	2010	2.4 / 2.8 mgd	3.9 mgd
	Task 240	2010	0.3 / 1.6 mgd	2.4 mgd
	Scenario 4	2030	0 / 0 mgd	0.9 mgd
Issaquah Int. Sec. 2	Scenario 1	2010	10.6 / 13 mgd	19.1 mgd
	Task 240	2020	0 / 6.2 mgd	11.8 mgd
	Scenario 4	2030	0 / 0 mgd	2.6 mgd
Issaquah Int. Sec. 1	Scenario 1	2010	13.3 / 15.7 mgd	21.8 mgd
	Task 240	2020	0.4 / 8.9 mgd	14.5 mgd
	Scenario 4	2030	0 / 0 mgd	5.3 mgd
Sunset P.S.	Scenario 1	2010	18.1 / 21 mgd	28.1 mgd
	Task 240	2010	5.2 / 14.2 mgd	20.9 mgd
	Scenario 4	2020	0 / 3.6 mgd	11.6 mgd
Heathfield P.S.	Scenario 1	2010	18.1 / 21 mgd	28.1 mgd
	Task 240	2010	5.2 / 14.2 mgd	20.9 mgd
	Scenario 4	2020	0 / 3.6 mgd	11.6 mgd
Eastgate Trunk[C]	Scenario 1	N/A	17.2 / 20.9 mgd	28.9 mgd
	Task 240	N/A	4.4 / 14.1 mgd	21.7 mgd
	Scenario 4	N/A	0 / 3.5 mgd	12.4 mgd

A. The additional capacity needed values assume the upstream facilities convey all wastewater to the given interceptor or pump station. If there is a reduction in flow upstream, the effects will cascade through the downstream conveyance.

B. Sunset and Heathfield Pump Stations need 8.2 mgd of additional capacity in 2010 and 17.2 mgd in 2020. The calculations are based on capacity test at Sunset Pump Station that showed a peak throughput of 21 mgd, not the 24 mgd firm capacity in the 1994 King County Offsite Facilities Manual. The working alternative assumes peak throughput can be increased to 21 mgd through minor station improvements.

C. The "Additional Capacity Needed" column for the Eastgate Trunk assumes the capacity restrictions at the top of the Eastgate Trunk are removed. The "When Additional Capacity Needed" column does not apply, because the Eastgate Trunk will not require additional capacity as long as the Sunset and Heathfield Pump Station capacities do not exceed 21 mgd.

APPENDIX D: OPERATION AND MAINTENANCE COST ASSUMPTIONS

MEMORANDUM 17226.241

DATE: MARCH 4, 2002

TO: RON KOHLER, KING COUNTY WTD

FROM: TADD GIESBRECHT, BROWN AND CALDWELL

CC: LORI JONES AND TONY DUBIN, BROWN AND CALDWELL

SUBJECT: SOUTH SAMMAMISH BASIN CONVEYANCE FACILITY O&M ASSUMPTIONS

During the February 11, 2002 CSI South Sammamish Task 240 Decision Workshop held at the King County King Street Center, it was indicated that storage facility costs and operational concerns needed to be investigated in greater detail. Also, in a discussion with Lori Jones of Brown and Caldwell, it was decided that a review of the assumptions used to generate operation and maintenance (O&M) costs for all conveyance facilities recommended during the Task 240 Decision Workshop was warranted. This memorandum summarizes the assumptions used for developing storage facility construction cost estimates and conveyance facility O&M cost estimates for the South Sammamish planning basin.

Storage facilities and gravity sewers were both part of the recommended alternative package (Package 1) presented during the Task 240 Decision Workshop. The next step in the CSI planning process is to refine the Task 240 recommended alternatives as part of Task 250. Recognizing that the recommended alternative package is a “working” alternative and subject to change, O&M assumptions for tunnels, force mains and pump stations are also included in this memo. Upon review of this memo, a meeting will be setup to discuss refining these assumptions and to identify O&M issues (specifically storage facility concerns) that need to be investigated in greater detail in order to prepare the Task 250 report.

STORAGE FACILITIES

For the construction cost estimate and O&M cost estimate, it was assumed that the storage facilities would be storage tunnels. Storage tanks were considered, but because of the sensitivity of the probable storage facility siting area (immediately south of Lake Sammamish) with respect to aesthetics and land acquisition, it was determined that storage tunnels would be carried through the cost estimating process. Furthermore, storage tunnels are preferred by King County and require less maintenance than storage tanks.

Construction Cost Estimate

The assumptions used to develop the storage facility cost estimates that were presented at the February 11, 2002 Decision Workshop are consistent with those described in the South Sammamish Basin, December 2001 Draft Task 240 Report. King County's CSI cost estimating tool (Tabula version 1.0) was used to develop the cost estimate. Generally, for storage tunnels the following assumptions were made:

- A 12-foot tunnel diameter to facilitate tunnel construction.
- Significant dewatering would be required because of the probable location of the storage facility near the south shore of Lake Sammamish.

Attachment A includes a detailed cost breakdown from Tabula for a 1.5MG storage tunnel. This attachment lists the detailed assumptions made within Tabula. The overall construction cost for a 1.5MG storage tunnel is estimated to be $8.5 million.

For purposes of reference, construction cost for a 1.5MG storage tank is estimated to be $16.5 million based on the following assumptions made within Tabula.

- Storage tank depth of 15 feet
- Gravity in/out flow
- Land acquisition required for "office/commercial" type property
- Odor control required
- Significant dewatering required

O&M Cost Estimate

O&M storage facility costs that were presented in the February 11, 2002 Decision Workshop were based on the spreadsheet used to develop O&M storage facility costs for the 1995 King County CSO update report. Included in Attachment B is a memo that describes the methodology and assumptions used to develop the O&M cost estimate in the spreadsheet. As mentioned above, for cost estimating purposes storage facilities were assumed to be storage tunnels and as such, were inputted into this spreadsheet as "off-line storage pipes". Table 1 summarizes the inputs used to generate the storage tunnel O&M cost estimate.

Table 1. Storage Facility O&M Cost Estimate Inputs

O&M Cost Component	*Input
Analysis Period	**50 years**
Net Discount Rate (O&M)	6.5%
Current Seattle ENR	**7341**
Off-Line Storage Pipes Maintenance Cost	$2,300/each/year
Off-Line Storage Pipes Inspection Cost	$800/each/year

* Note that bold values are changed from the 1995 King County CSO update report spreadsheet; all other values are unchanged.

Based on this spreadsheet, the overall O&M cost for a storage tunnel is $3,100/year.

For purposes of reference, O&M storage facility cost for a rectangular storage tank based on the same spreadsheet is $67,800/year (based on a gravity in/out flow configuration). Table 2 summarizes the O&M components that comprise this overall O&M cost.

Table 2. Rectangular Storage Tank O&M Components

Rectangular Storage Tank O&M Component	O&M Cost, $/year
Cleaning	$6,500
Inspection	$6,600
Maintenance	$42,700
Energy	$0
Chemicals	$12,000
Total	$67,800

Assuming 1 overflow event/year

Comment: Add non-pumping power costs (ventilation etc.) at 10% of pumping power costs

OTHER CONVEYANCE FACILITIES

Other conveyance facilities that will potentially comprise the South Sammamish Basin conveyance solution are gravity sewers, microtunnels, force mains and pump stations.

Facility Sizing

Assumptions related to sizing of conveyance facilities that affect O&M are summarized in Table 3. These assumptions are consistent with those described in the South Sammamish Basin, December 2001 Draft Task 240 Report and were used to develop the cost estimate.

Table 3. Conveyance Facility Sizing Assumptions

Item	Assumption
Pump Stations	Maximum TDH per single-stage pump station would be 200 feet. If the required TDH would slightly exceed 200 feet, this assumption could be deviated from to avoid an additional pump station. If TDH would be between 240 feet and 340 feet, it was assumed that a two-stage pump station would be used rather than 2 separate single-stage pump stations. It was assumed that a two-stage pump station would cost 75% more than a single-stage pump station to account for additional pumps, controls and building area.
Pipelines	Pipes would be sized to maintain a velocity between 2 and 8 ft/s. Where gravity sewer and force main pipelines depths would exceed 25 feet, pipeline installation was assumed to be by alternative tunneling methods (microtunneling and horizontal directional drilling (HDD)). Microtunnel shaft spacing was set at approximately 1,500 feet.

O&M Cost Estimate

All O&M cost estimates for conveyance facilities were based on the spreadsheet from the 1995 King County CSO update report as described above for the storage facilities. Table 4 summarizes the cost estimate assumptions used for gravity sewers, tunnels, force mains and pump stations.

Table 4. Conveyance Facility O&M Cost Estimate Inputs

O&M Cost Component	*Input
Analysis Period	50 years
Net Discount Rate (O&M)	6.5%
Net Discount Rate (Energy)	6.5%
Current Seattle ENR	**7341**
Pipelines:	
Gravity Sewer Maintenance Cost	$1.00/ft/year
Force Main Maintenance Cost	$0.02/ft/year
Tunnel Inspection Cost	$4/ft/10 years
Pump Stations:	
Power Cost	**$0.05/kwh**
Days of Operation	365 days/year

* Note that bold values are changed from the 1995 King County CSO update report spreadsheet; all other values are unchanged.

ATTACHMENT A

COST DETAIL FOR 1.5MG STORAGE TUNNEL

(output from Tabula version 1.0)

Cost Calculations for Tunnel: 1.5 MG Tunnel

Project year: 2001

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.). Unless added as an Additional Costs item in the estimate, this cost does NOT include land acquisition costs.

Assumptions

Construction Year: 2001
Inside Diameter: 12 ft.
Length: 1800 ft
Dewatering: Significant
Launch Shaft Existing Utilities: Average
Launch Shaft Excavation Depth: 20 ft
Launch Shaft Surface Restoration: Hydroseed
Retrieval Shaft Excavation Depth: 20 ft
Retrieval Shaft Surface Restoration: Hydroseed
Retrieval Shaft Existing Utilities: Average
Tunnel Easement Length: 0 ft
Easement Type: None
Launch Shaft Footprint: Oversized
Retrieval Shaft Footprint: Oversized

Tunnel Geometry

Outer Diameter	13.3 ft
Spoils Volume	9,300 CY

Launch Shaft Geometry

Width	67 ft
Length	160 ft
Footprint	10,700 SF
Volume	7,940 CY
Easement Footprint	18,400 SF

Retrieval Shaft Geometry

Width	54 ft
Length	80 ft
Footprint	4,320 SF
Volume	3,200 CY
Easement Footprint	9,240 SF

Miscellaneous

Spoils Loads	931 loads

Unit Costs (Basis 1999)

Item	Quantity	Unit	Unit Cost	ItemCost
Spoils Haul	9,304	CY	9	83,700
Launch Shaft Excavation	7,941	CY	9	71,500
Launch Shaft Shoring	9,080	SF	41	372,000
Launch Shaft Existing Utilities	10,720	SF	6	64,300
Launch Shaft Backfill	7,941	CY	9	71,500
Launch Shaft Surface Restoration	1,191	SY	5	5,960
Retrieval Shaft Excavation	3,200	CY	9	28,800
Retrieval Shaft Shoring	5,360	SF	41	220,000
Retrieval Shaft Existing Utilities	4,320	SF	6	25,900
Retrieval Shaft Backfill	3,200	CY	9	28,800
Retrieval Shaft Surface Restoration	480	SY	5	2,400
Tunnel Dewatering	1	LS	60,000	60,000
TBM Procurment	1	LS	2,500,000	2,500,000
Tunnel Boring	1,800	ft	2,200	3,960,000
		Year 1999 subtotal		7,490,000

Mobilization/Demobilization at 10%		1.10
Multiplier from ENRCCI 7137 (1999) to 7341 (2001)		1.03
	Effective Multiplier	1.13
	Subtotal	8,480,000

Total: $8,480,000

ATTACHMENT B

O&M Cost Estimate Methodology and Assumptions

O&M COST ESTIMATE METHODOLOGY AND ASSUMPTIONS

ECONOMIC ASSUMPTIONS

Operation and Maintenance costs will be compared with capital costs based on present worth. Inflation rates and discount rates were provided by Metro for both O&M and energy categories. The values are as follows:

Inflation Rate:

O&M:	2.80%
Energy:	3.55%

Discount Rate:

O&M:	6.50%
Energy:	6.50%

Analysis Period: 20 Years

ENR: 5747 (Seattle - May 1994)

Operation and Maintenance Labor Rates: $32.0/Hr.

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1. GRAVITY SEWER/COMBINED SEWER PIPELINES

A. Maintenance:

Item: Maintenance and inspection expenditures
Methodology: Metro currently spends approximately $1.5 million per year on sewer inspection, maintenance, repairs, T.V. inspection, and cleaning. The current estimate is that Metro has jurisdiction over 270 miles of sewer. This computes to an O&M estimate of approximately $1.05/LF of pipe. In the 1985 O&M document prepared by B&C, total 1984 maintenance expenditures (including maintenance labor plus other direct costs) for the maintenance of 400,000 LF of West Division gravity sewer lines was computed as $0.09/LF (ENR 4550) Escalated to current ENR levels, this annual expenditure equals just over $0.11/LF. However as stated in the document, "...interceptor inspections are frequently done by contract and the cost for these contracts is not reflected in the divisional O&M budget reports.
Conclusion: Use $1.00/LF for total annual maintenance costs for combined sewer and dedicated sewer lines.

2. FORCE MAINS

A. Maintenance

Item: Maintenance and inspection expenditures
Methodology: Metro visually inspects the ground surface above all force main alignments on an annual basis. This inspection is performed to identify leaks in the force mains. According to Metro, a two person crew performs this type of inspection for the entire 120,000 LF of force mains under Metro jurisdiction in a 5 day work week. Assuming labor costs of $32.00/hr, the inspection costs for force mains equals approximately $0.02/LF per year.
Conclusion: Use $0.02/LF and assume no other maintenance expenditures other than those stated above.

3. REGULATING STRUCTURES AND FLOW CONTROL STRUCTURES

A. Maintenance

Item: Regular inspection
Methodology: Based on Metro staff estimates, inspection frequency for regulators is approximately twice per week with a 2 person inspection crew. Assume that the crew spends 2 hours at each regulator. Hourly wages are assumed as $32/hr. Therefore annual inspection expenditures for regulators will be estimated as (2persons/crew)x(1crew/visit)x(2hrs/visit)x($32/hr/person)x(2 visits/week)x(52weeks/yr) = $13,312/year.
Conclusion: Assume inspection expenditure of $13,000/year for each regulator station.

Item: Regular maintenance
Methodology: Based on Metro staff estimates, maintenance frequency for regulators is approximately four times per year with a 1 person maintenance crew. Assume that the crew spends 4 hours at each regulator. Hourly wages are assumed as $32/hr. Therefore annual maintenance expenditures for regulators will be estimated as 4x4x1x32 = $512/year.
Conclusion: Assume maintenance expenditure of $500/year for each regulator station.

4. PUMP STATIONS

Due to lack of current, detailed information, all maintenance and operation estimates will be based upon the March 1985 "Operations and Maintenance Cost

Curves" document. The curves are based not on peak capacity of the pump stations but instead on peak capacity multiplied by the head of the pump station (therefore expressed in terms of mgd-ft). Therefore an estimate of the total dynamic head will be made for each of our pump stations. There will be three curves that will be used to compute the total O&M pump station estimates. All three are listed below. These curves are based on an ENR of 4550, and the costs obtained from the curves will be escalated to 1994 dollars by using the May 1994 ENR figure.

- Total Operations Costs ($) vs. Pump Station Capacity (MGD-FT)
- Total Maintenance Costs ($) vs. Pump Station Capacity (MGD-FT)
- Total Power Costs ($) vs. Pump Station Capacity (MGD-FT)

A determination will have to be made as to the number of days per year each pump station will be operating. This assumption will not have to be made for pump stations built as part of a storage facility since this frequency assumption will have to be made for the storage facility itself. Once this assumption is made, then a factor will be applied to the costs obtained from the above curves which will account for the intermittent operation of the pump station.

5. PRIMARY SEDIMENTATION FACILITIES

Item: Operation and Maintenance and Energy Expenditures
Methodology: Data is available for 1984 operations, maintenance, and energy costs (ENR 4550) for each of the Richmond Beach, Carkeek, Alki, Renton and West Point treatment facilities. Based on this data, graphs were prepared which plotted "Treated MG/Year" vs. "Cost/MG" for the operation expenditures, maintenance expenditures, and energy expenditures for primary sedimentation at each of the treatment plants. A best fit power curve was fit to each of the three graphs. Based on these power curves, expected annual expenditures for operation, maintenance, and energy were estimated for the Denny and Duwamish sites, using the assumption that 556 MG will be treated annually at the Denny facility and that 727 MG will be treated annually at the Duwamish facility.

Item: Chemical Costs
Methodology:
Chlorination: Chlorine costs will be estimated based on 30 mg/l available chlorine on the annual estimated overflow volume. Assume use of hypochlorite @ $0.6/gal, 10.35 lb./gal and 8% solution. Gallons of NaOCl required is then calculated as:

NaOCl (gal/year) = (Volume, MG/yr) * 8.34 * 30.0/(0.08*10.35)

Dechlorination: Add Sodium Bisulfite for dechlorination. Assume Sodium Bisulfite at 38% solution and $2.30/gal. Gallons of Sodium Bisulfite required is then calculated as:

(gal/year) = (NaOCl gal/year)/(38%/8%)

6. OFFSITE CSO TREATMENT FACILITIES

Item: Operation and Maintenance and Energy Expenditures
Methodology: Data is available for 1984 operations, maintenance, and energy costs (ENR 4550) for each of the Richmond Beach, Carkeek, Alki, Renton and West Point treatment facilities. Based on this data, graphs were prepared which plotted "Treated MG/Year" vs. "Cost/MG" for the operation expenditures, maintenance expenditures, and energy expenditures for primary sedimentation at each of the treatment plants. A best fit power curve was fit to each of the three graphs. Based on these power curves, expected annual expenditures for operation, maintenance, and energy were estimated for the offsite facilities. Because offsite treatment facilities require less operators and maintenance staff to run, 1/2 of an FTE (Full-Time Equivalent @ 1850 hrs/year and $32/hr) will be subtracted from the total O&M annual dollar expenditures estimated from the above equations. Energy costs for the offsite facilities were not adjusted from the equations developed for the primary sedimentation facilities, and thus are assumed to be equal to those for the primary sedimentation facilities.

Item: Chemical Costs
Methodology:
Chlorination: Chlorine costs will be estimated based on 30 mg/l available chlorine on the annual estimated overflow volume. Assume use of hypochlorite @ $0.6/gal, 10.35 lb./gal and 8% solution. Gallons of NaOCl required is then calculated as:

NaOCl (gal/year) = (Volume, MG/yr) * 8.34 * 30.0/(0.08*10.35)

Dechlorination: Add Sodium Bisulfite for dechlorination. Assume Sodium Bisulfite at 38% solution and $2.30/gal. Gallons of Sodium Bisulfite required is then calculated as:

(gal/year) = (NaOCl gal/year)/(38%/8%)

7. TUNNELS

Item: Regular inspection

Methodology: Metro conducts T.V. inspection of concrete tunnels on a 10-15 year rotation and T.V. inspections of brick lined tunnels on a 5 year rotation. All inspection work is done by outside contract. A recent inspection contract for the Hazelwood Tunnel was for inspection of 12,000 LF of tunnel and cost $26,600 ($2.22/LF) Metro staff also felt that tunnel inspection contracts could actually range between $3.00/LF and $6.00/LF.
Conclusion: Assume that new tunnels will be inspected on a 10 year rotation and the unit cost for the tunnel inspection will be assumed to be $4.00/LF

8. SEPARATION

Item: Compost filter maintenance and media replacement
Methodology: In a review of the manufactures literature for compost filters, it was concluded that the top 20 cubic yards of the compost filter material should be replaced annually, and the remainder of the compost filter material should be replaced on a four year cycle. It was estimated that annual maintenance and replacement costs per compost filter facility are approximately $1,800 per facility (including removal, replacement, disposal, and transport). As part of the annual maintenance expenditures, it is assumed that a two person crew will visit each facility for 1 hour, twice per year. Labor is assumed as $32.00 per hour, including benefits. The four year cycle, filter material replacement costs were estimated as $1,400 per facility (including removal, replacement, disposal, and transport). As per assumptions in the Task 4.0 report entitled "Development of Alternatives", in single family residential areas, assume 1 compost filter per 5 separated acres, and in commercial/industrial/multi-family areas, assume 1 compost filter per 4 separated acres.
Conclusion: Assume annual maintenance, inspection, and compost replacement costs to be $1,900 per facility per year. In addition, every four years an additional $1,400 dollars per facility will be spent for additional compost filter material replacement

B. Maintenance/Inspection of catch basins and storm sewers.

Item: Catch basin cleaning
Methodology: Based on conversations with the City of Seattle Drainage and Wastewater Utility, in 1993, the City cleaned 9,855 inlets and catch basins and spent approximately $500,000 (not including overhead) to do so. This estimate yields a cleaning cost of approximately $50 per catch basin. Staff at the Drainage and Wastewater Utility were unable to estimate the frequency of cleaning that catch basins require, due any unknown parameters such as debris loading, surrounding land use, etc.. However, catch basins are cleaned once the debris

level in the catch basin attains a level within 18" of the catch basin outlet. An assumption will have to be made as to the frequency that all brand new catch basins will have to be cleaned.
Conclusion: Assume $50/catch basin for cleaning and disposing of sediment. Catch basin cleaning will be assumed on a 5 year cycle.

Item: Catch basin inspections
Methodology: Based on conversations with the City of Seattle Drainage and Wastewater Utility, catch basin inspections are conducted annually on the 30,000 catch basins within the city. Staff at Drainage and Wastewater Utility estimated that a crew of two can inspect 58 catch basins in an 8 hour day. Assume $32 per hour for labor. Using this data, inspection costs per catch basin equal approximately $8.83.
Conclusion: Assume $8/catch basin for annual inspection of catch basins.

Item: Regular T.V. inspection of new storm lines
Methodology: Based on conversations with Seattle Engineering Department, T.V. inspection expenditures within the first quarter of 1994 equated to $0.71/LF for all pipelines (both sewer and storm). The city ideally would like to inspect pipelines within their jurisdiction on a 20 year rotation, perhaps more frequently for sewer lines.
Conclusion: Assume T.V. inspection of new storm lines will be performed on a 20 year rotation. Assume $0.75/LF for this inspection.

Item: Regular cleaning of storm drain pipelines.
Methodology: Based on conversations with Seattle Engineering Department, in the first quarter of 1994, $7,200 were spent on cleaning of 10,362 LF of storm drain pipes. Staff at Drainage and Wastewater Utility stated that cleaning of storm lines is done very infrequently, and that in the grand scheme of maintenance costs, cleaning is a negligible item. The City emphasizes a strong maintenance and inspection program for catch basins and drain inlets as the means to keep the storm system free of debris and sediments.
Conclusion: Assume no money will be allocated for cleaning of storm drain lines.

C. Other

Item: Metro Source Control Budget within the Storm Water Management Program
Methodology: Metro budgets money annually for source control inspections, review of storm water pollution prevention controls, review and modification of emergency spill procedures, and education and outreach within industrial

drainage basins that have separated storm sewer systems. This money is budgeted for source control inspections, monitoring that storm water discharge permits are being complied with, reviewing of storm water pollution prevention plans, education and outreach programs, and reviewing of storm water sampling results. In 1994, Metro budgeted $69,624 for this work within the Densmore Drain and in 1995 they have budgeted $147,811 for both the Densmore Drain and Lander basins. On a basis of cost per unit area of separtion, these budget figures are approximately equivalent to $60/acre.
Conclusion: Assume annual expenditure of $60/acre for each separated drainage basin, to be used for the source control work described above.

9. CIRCULAR STORAGE TANKS

A. Operation

Item: Annual operating costs associated with energy consumption for pumps.
Methodology: For the most part, each storage facility is located in the vicinity of one of Metro's overflow regulator stations, and thus will be receiving and storing the overflow volume from each regulator station. Overflow events occur throughout the year, and the number of overflow events that occur differ amongst all of the regulator stations. To estimate the number of hours per year that the pump stations within these storage facilities will be operating on an annual basis, the number of annual number of overflow events at each regulator station was obtained from Metro. This frequency determination is based on the 1982-1983 baseline conditions. An assumption was then made that the number of days per year that the pumps will be operating will be two times the number of overflow events. This assumes that one overflow event will require 1.5 days to be pumped out (for the design of the storage facilities, the pumps were sized so as to be capable of pumping a full tank in a 2 day time period. Smaller overflow events will of course overflow smaller volumes and will therefore require less time to pump out.) For example, if at a particular regulator station, overflow frequency was determined to be 20 times per year, then it is assumed that the pumps will be operating for 30 days per year, at peak flow rate.

Horsepower is calculated as

Hp= ((Q) x (H) x (Specific Gravity of Water))/550 * Pump Efficiency

where, Q = Peak design rate of pump station (MGD)
H = Total dynamic head of pump station (ft)
Specific Gravity = 62.4 lb/cubic feet
Pump Efficiency = 0.70

KW requirements are assumed to equal (Pump Hp x(0.746 KW/Hp))/Motor Efficiency

Annual usage of pump station equals 1.5 times the number of overflow events per year, in hours (as described above)

Annual power costs = KW x Usage (hours) x (cost per KWH)
Conclusion: Use the above equations to compute $/year for energy consumption for pump stations located in storage facilities.

Item: Annual operating costs associated with energy consumption for aeration
Methodology: Assume 10 Hp per MG for aeration and mixing in storage facility. Assume that aeration and mixing will operate throughout the rainy season (assume 1/2 year = 4383 hours)
Conclusion: Use the following equation to develop annual energy costs for aeration and mixing:

> **Total Hp= (Volume of Tank MG)x(10 hp/MG)x(.04 $/kwh)x (4383 hrs/year)**

Item: Annual operating costs associated with energy consumption and chemical consumption for odor control.
Methodology: Operating costs were estimated assuming forced air systems providing one air change per hour and acitvated carbon control facilities. Annual costs to change the carbon at 5 year intervals and power to operate the systems were estimated on the basis of unit storage volume.
Conclusion: Use the following equation to develop annual operating costs for odor control

> **Total horsepower = 6*storage volume in MG**
> **Annual chemical cost = (37000*storage volume in MG)^-0.3 - 4300)*storage volume in MG**

B. Maintenance:

Item: Cleaning of storage facilities.
Methodology: City of Seattle maintains (2) 1.5 MG circular storage facilities. Annual cleaning of these facilities require 5 crew days each with a crew size of 5 people. Therefore, we will assume 200 Hours/1.5 MG/Year which equals 133 Hours/MG/Year for labor associated with cleaning storage tanks.. Hourly pay rates for the crew will be assumed to be $32/hour including benefits.
Conclusion: Assume annual costs for cleaning circular storage facilities will be $4,300 per MG of storage.

Item: Regular Inspection of Circular Storage Facilities.

Methodology: According to conversations with the City's Engineering Department, they schedule regular inspections once per week to check the electrical systems for their 1.5 MG storage facilities. This requires a one person crew one hour to perform the inspection. Assume labor rate of $32/hr.
Conclusion: Assume annual inspection costs for circular storage facilities will be $1,600 per facility.

10. RECTANGULAR STORAGE FACILITIES

A. Operation

Item: Annual operating costs associated with energy consumption for pumps.
Methodology: For the most part, each storage facility is located in the vicinity of one of Metro's overflow regulator stations, and thus will be receiving and storing the overflow volume from each regulator station. Overflow events occur throughout the year, and the number of overflow events that occur differ amongst all of the regulator stations. To estimate the number of hours per year that the pump stations within these storage facilities will be operating on an annual basis, the number of annual number of overflow events at each regulator station was obtained from Metro. This frequency determination is based on the 1982-1983 baseline conditions. An assumption was then made that the number of days per year that the pumps will be operating will be two times the number of overflow events. This assumes that one overflow event will require 1.5 days to be pumped out (for the design of the storage facilities, the pumps were sized so as to be capable of pumping a full tank in a 2 day time period. Smaller overflow events will of course overflow smaller volumes and will therefore require less time to pump out.) For example, if at a particular regulator station, overflow frequency was determined to be 20 times per year, then it is assumed that the pumps will be operating for 30 days per year, at peak flow rate.

Horsepower is calculated as

Hp= ((Q) x (H) x (Specific Gravity of Water))/550 * Pump Efficiency

where, Q = Peak design rate of pump station (MGD)
H = Total dynamic head of pump station (ft)
Specific Gravity = 62.4 lb/cubic feet
Pump Efficiency = 0.70

KW requirements are assumed to equal (Pump Hp x(0.746 KW/Hp))/Motor Efficiency

Annual usage of pump station equals 1.5 times the number of overflow events per year, in hours (as described above)

Annual power costs = KW x Usage (hours) x (cost per KWH)
Conclusion: Use the above equations to compute $/year for energy consumption for pump stations located in storage facilities.

Item: Annual operating costs associated with energy consumption for aeration
Methodology: Assume 10 Hp per MG for aeration and mixing in storage facility. Assume that aeration and mixing will operate throughout the rainy season (assume 1/2 year = 4383 hours)
Conclusion: Use the following equation to develop annual energy costs for aeration and mixing:

> **Total Hp= (Volume of Tank MG)x(10 hp/MG)x(.04 $/kwh)x (4383 hrs/year)**

Item: Annual operating costs associated with energy consumption and chemical consumption for odor control.
Methodology: Same as for Circular Storage above.

B. Maintenance

Item: Cleaning of storage facilities.
Methodology: Use same methodology and assumptions as for the City's circular storage facilities.
Conclusion: Assume annual costs for cleaning circular storage facilities will be $4,300 per MG of storage.

Item: Regular Inspection of Rectangular Storage Facilities.
Methodology: Use same methodology and assumptions as for the City's circular storage facilities. However, since the rectangular facilities are quite a bit larger than the circular facilities, we will assume a two person crew inspecting the facilities once per week for a two hour time period per visit.
Conclusion: Assume annual expenditures for inspection of rectangular storage facilities to be twice as much as for the circular facilities. Assume $6,600 per facility.

11. BOX STORAGE FACILITIES

A. Operation:

Item: Annual operating costs associated with energy consumption for pumps.
Methodology: For the most part, each storage facility is located in the vicinity of one of Metro's overflow regulator stations, and thus will be receiving and storing the overflow volume from each regulator station. Overflow events occur throughout the year, and the number of overflow events that occur differ amongst all of the regulator stations. To estimate the number of hours per year that the pump stations within these storage facilities will be operating on an annual basis, the number of annual number of overflow events at each regulator station was obtained from Metro. This frequency determination is based on the 1982-1983 baseline conditions. An assumption was then made that the number of days per year that the pumps will be operating will be two times the number of overflow events. This assumes that one overflow event will require 1.5 days to be pumped out (for the design of the storage facilities, the pumps were sized so as to be capable of pumping a full tank in a 2 day time period. Smaller overflow events will of course overflow smaller volumes and will therefore require less time to pump out.) For example, if at a particular regulator station, overflow frequency was determined to be 20 times per year, then it is assumed that the pumps will be operating for 30 days per year, at peak flow rate.

Horsepower is calculated as

Hp= ((Q) x (H) x (Specific Gravity of Water))/550 * Pump Efficiency

where, Q = Peak design rate of pump station (MGD)
H = Total dynamic head of pump station (ft)
Specific Gravity = 62.4 lb/cubic feet
Pump Efficiency = 0.70

KW requirements are assumed to equal (Pump Hp x(0.746 KW/Hp))/Motor Efficiency

Annual usage of pump station equals 1.5 times the number of overflow events per year, in hours (as described above)

Annual power costs = KW x Usage (hours) x (cost per KWH)
Conclusion: Use the above equations to compute $/year for energy consumption for pump stations located in storage facilities.

Item: Annual operating costs associated with energy consumption for aeration

Methodology: Assume 10 Hp per MG for aeration and mixing in storage facility. Assume that aeration and mixing will operate throughout the rainy season (assume 1/2 year = 4383 hours)

Conclusion: Use the following equation to develop annual energy costs for aeration and mixing:

Total Hp= (Volume of Tank MG)x(10 hp/MG)x(.04 $/kwh)x(4383 hrs/year)

Item: Annual operating costs associated with energy consumption and chemical consumption for odor control.
Methodology: Same as for Circular Storage above.

B. Maintenance:

Item: Cleaning of storage facilities.
Methodology: Use same methodology and assumptions as for the City's circular storage facilities.
Conclusion: Assume annual costs for cleaning circular storage facilities will be $4,300 per MG of storage.

Item: Regular Inspection of Rectangular Storage Facilities.
Methodology: Use same methodology and assumptions as for the City's circular storage facilities. However, since the box storage facilities are quite a bit larger than the circular facilities, we will assume a two person crew inspecting the facilities once per week for a two hour time period per visit.
Conclusion: Assume annual expenditures for inspection of box storage facilities to be $6,600 per facility.

12. OFF-LINE STORAGE PIPES

A. Maintenance:

Item: Cleaning of storage facilities.
Methodology: City of Seattle maintains (36) in-line pipe storage facilities. These facilities require 1-3 crew days each with a crew size of 3 people on an annual basis. Hourly pay rates for the crew will be assumed to be $24/hour including benefits.
Conclusion: Assume 3 crew days per cleaning. Therefore, annual cleaning costs equal
(3 days/visit)x(1 visit/year)x(3 people/day)x(8 hrs/day)x(32 $/hr) = $2,304/year, say $2,300 per year.

Item: Regular Inspection of Circular Storage Facilities.
Methodology: According to conversations with the City's Engineering Department, they schedule regular inspections once per month for their pipe storage facilities. This requires a two person crew one hour to perform the inspection. Hourly pay rates for the crew will be assumed to be $32/hour including benefits.
Conclusion: Annual inspection costs equal (1 hour/visit)x(12 visit/year)x(2 people/hour)x(32 $/hour) or $768 per year, say $800 per year.

13. OUTFALLS

A. Operation and Maintenance

Item: Total operation and Maintenance expenditures including labor plus other direct costs
Methodology: In discussions with Metro staff, diffuser outfalls are inspected on a 5 year rotation as part of NPDES requirements. The Renton outfall inspection contract, a typical deep marine outfall, cost Metro $35,000. Metro staff estimated that shallower, more accessible outfall inspections may run between $1,000 and $5,000 to inspect annually. O&M cost curves, developed by Brown and Caldwell in March 1985 were based on actual Metro expenditures in 1984. Based on the information presented in these cost curves, annual expenditures for O&M for the Michigan, Brandon, and Hanford outfalls (ENR 4550) was $3877, $3947, and $3485 respectively. In terms of 1994 dollars, these costs would be $4896, $4985, and $4402 (ENR 5747) respectively. Upon further review of these cost curves, Metro staff felt that $1,100 per year per outfall would be a better estimate for each of the Michigan, Brandon, and Hanford outfalls.
Conclusion: Assume all outfalls will be inspected on a 5 year rotation. For marine outfalls, assume annual O&M expenditures of $1,100 in addition to $35,000 inspection costs incurred every 5 years. For lake outfalls, assume annual O&M expenditures of $1,100 in addition to $5,000 inspection costs incurred every 5 years.

APPENDIX E: REFINED PLANNING-LEVEL CONSTRUCTION COST ESTIMATE DETAILS

ISSAQUAH HIGHLANDS RELIEF SEWER ROUTE 1:

Cost Calculations for Pipe: 15-in gravity sewer

Project year: 2001

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Construction Year: 2001
Length: 7850 ft
Conduit Type: Gravity Sewer
Depth of Cover: 10 ft
Trench Backfill Type: Imported
Manhole Spacing: Average (500 ft)
Existing Utilities: Average
Dewatering: Minimal
Pavement Restoration: Half Width - Arterial (22 ft)
Traffic: Heavy
Land Acquisition: None
Required Easements: None
Trench Safety: Standard
Pipe Diameter: 15 in.

Geometry

Outer Diameter	1.67	ft
Trench Width	4.67	ft
Excavation Depth	12.7	ft
Complete Surface Rest. Width	6.67	ft

Unit Costs (Basis 1999)

Item	Quantity	Unit	Unit Cost	ItemCost
Excavation	17,186	CY	10.00	172,000
Backfill	12,211	CY	25.00	305,000
Complete Pavement Restoration	5,815	SY	50.00	291,000
Overlay Pavement Restoration	13,374	SY	20.00	267,000
Trench Safety	198,867	SF	0.50	99,400
Spoil Load and Haul	17,186	CY	10.00	172,000

Pipe Unit Material Cost 7,850 lf 18.00 141,000
Pipe Installation 7,850 lf 20.00 157,000
Place Pipe Zone Fill 4,341 CY 25.00 109,000
Manholes 16 MH 3,000.00 48,000
Existing Utilities 7,850 lf 30.00 236,000
Dewatering 7,850 lf 20.00 157,000
Traffic Control 7,850 lf 10.00 78,500
Year 1999 subtotal 2,230,000

Mobilization/Demobilization at 10% 1.10
Multiplier from ENRCCI 7137 (1999) to 7341 (2001) 1.03
Effective Multiplier 1.13

Year 1999 subtotal 2,230,000

Total: $2,530,000

ISSAQUAH HIGHLANDS RELIEF SEWER ROUTE 2:

Cost Calculations for Pipe: 15-in gravity sewer

Project year: 2001

> The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

> Construction Year: 2001
> Length: 6450 ft
> Conduit Type: Gravity Sewer
> Depth of Cover: 10 ft
> Trench Backfill Type: Imported
> Manhole Spacing: Average (500 ft)
> Existing Utilities: Average
> Dewatering: Minimal
> Pavement Restoration: Half Width - Arterial (22 ft)
> Traffic: Heavy
> Land Acquisition: None
> Required Easements: None
> Trench Safety: Standard
> Pipe Diameter: 15 in.

Geometry

Outer Diameter	1.67	ft
Trench Width	4.67	ft
Excavation Depth	12.7	ft
Complete Surface Rest. Width	6.67	ft

Unit Costs (Basis 1999)

Item	Quantity	Unit	Unit Cost	ItemCost
Excavation	14,121	CY	10.00	141,000
Backfill	10,033	CY	25.00	251,000
Complete Pavement Restoration	4,778	SY	50.00	239,000
Overlay Pavement Restoration	10,989	SY	20.00	220,000
Trench Safety	163,400	SF	0.50	81,700
Spoil Load and Haul	14,121	CY	10.00	141,000

Pipe Unit Material Cost	6,450	lf	18.00	116,000
Pipe Installation	6,450	lf	20.00	129,000
Place Pipe Zone Fill	3,566	CY	25.00	89,200
Manholes	13	MH	3,000.00	39,000
Existing Utilities	6,450	lf	30.00	194,000
Dewatering	6,450	lf	20.00	129,000
Traffic Control	6,450	lf	10.00	64,500
	Year 1999 subtotal			1,830,000

Mobilization/Demobilization at 10% 1.10
Multiplier from ENRCCI 7137 (1999) to 7341 (2001) 1.03
Effective Multiplier 1.13

Year 1999 subtotal 1,830,000

Total: $2,070,000

ISSAQUAH HIGHLANDS RELIEF SEWER ROUTE 3:

Cost Calculations for Pipe: 15-in gravity sewer

Project year: 2001

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Construction Year: 2001
Length: 5050 ft
Conduit Type: Gravity Sewer
Depth of Cover: 10 ft
Trench Backfill Type: Imported
Manhole Spacing: Average (500 ft)
Existing Utilities: Average
Dewatering: Minimal
Pavement Restoration: Half Width - Arterial (22 ft)
Traffic: Light
Land Acquisition: None
Required Easements: None
Trench Safety: Standard
Pipe Diameter: 15 in.

Geometry

Outer Diameter	1.67	ft
Trench Width	4.67	ft
Excavation Depth	12.7	ft
Complete Surface Rest. Width	6.67	ft

Unit Costs (Basis 1999)

Item	Quantity	Unit	Unit Cost	ItemCost
Excavation	11,056	CY	10.00	111,000
Backfill	7,856	CY	25.00	196,000
Complete Pavement Restoration	3,741	SY	50.00	187,000
Overlay Pavement Restoration	8,604	SY	20.00	172,000
Trench Safety	127,933	SF	0.50	64,000
Spoil Load and Haul	11,056	CY	10.00	111,000

Pipe Unit Material Cost	5,050	lf	18.00	90,900
Pipe Installation	5,050	lf	20.00	101,000
Place Pipe Zone Fill	2,792	CY	25.00	69,800
Manholes	11	MH	3,000.00	33,000
Existing Utilities	5,050	lf	30.00	152,000
Dewatering	5,050	lf	20.00	101,000
Traffic Control	5,050	lf	5.00	25,300
	Year 1999 subtotal			1,410,000

Mobilization/Demobilization at 10% 1.10
Multiplier from ENRCCI 7137 (1999) to 7341 (2001) 1.03
Effective Multiplier 1.13

Year 1999 subtotal 1,410,000

Total: $1,600,000

SAMMAMISH PLATEAU NORTH DIVERSION (THREE SECTIONS)

STA 0+00 to 32+00, Cost Calculations for Pipe: 21-in gravity section

Project year: 2001

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Construction Year: 2001
Length: 3200 ft
Conduit Type: Gravity Sewer
Depth of Cover: 10 ft
Trench Backfill Type: Imported
Manhole Spacing: Average (500 ft)
Existing Utilities: Complex
Dewatering: Minimal
Pavement Restoration: Half Width - Arterial (22 ft)
Traffic: Heavy
Land Acquisition: None
Required Easements: None
Trench Safety: Standard
Pipe Diameter: 24 in.

Geometry

Outer Diameter	2.5	ft
Trench Width	5.75	ft
Excavation Depth	13.5	ft
Complete Surface Rest. Width	7.75	ft

Unit Costs (Basis 1999)

Item	Quantity	Unit	Unit Cost	ItemCost
Excavation	9,200	CY	10.00	92,000
Backfill	6,133	CY	25.00	153,000
Complete Pavement Restoration	2,756	SY	50.00	138,000
Overlay Pavement Restoration	5,067	SY	20.00	101,000
Trench Safety	86,400	SF	0.50	43,200
Spoil Load and Haul	9,200	CY	10.00	92,000

Pipe Unit Material Cost	3,200	lf	30.00	96,000
Pipe Installation	3,200	lf	30.00	96,000
Place Pipe Zone Fill	2,485	CY	25.00	62,100
Manholes	7	MH	5,000.00	35,000
Existing Utilities	3,200	lf	80.00	256,000
Dewatering	3,200	lf	20.00	64,000
Traffic Control	3,200	lf	20.00	64,000
	Year 1999 subtotal			1,290,000

Mobilization/Demobilization at 10% 1.10
Multiplier from ENRCCI 7137 (1999) to 7341 (2001) 1.03
Effective Multiplier 1.13

Year 1999 subtotal 1,290,000

<u>SubTotal: $1,460,000</u>

STA 32+00 to 84+00, Cost Calculations for Pipe: 24-in gravity section

Project year: 2001

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Construction Year: 2001
Length: 5200 ft
Conduit Type: Gravity Sewer
Depth of Cover: 10 ft
Trench Backfill Type: Imported
Manhole Spacing: Average (500 ft)
Existing Utilities: Complex
Dewatering: Minimal
Pavement Restoration: Half Width - Arterial (22 ft)
Traffic: Heavy
Land Acquisition: None
Required Easements: None
Trench Safety: Standard
Pipe Diameter: 24 in.

Geometry

Outer Diameter	2.5	ft
Trench Width	5.75	ft
Excavation Depth	13.5	ft
Complete Surface Rest. Width	7.75	ft

Unit Costs (Basis 1999)

Item	Quantity	Unit	Unit Cost	ItemCost
Excavation	14,950	CY	10.00	150,000
Backfill	9,967	CY	25.00	249,000
Complete Pavement Restoration	4,478	SY	50.00	224,000
Overlay Pavement Restoration	8,233	SY	20.00	165,000
Trench Safety	140,400	SF	0.50	70,200
Spoil Load and Haul	14,950	CY	10.00	150,000
Pipe Unit Material Cost	5,200	lf	30.00	156,000
Pipe Installation	5,200	lf	30.00	156,000
Place Pipe Zone Fill	4,038	CY	25.00	101,000
Manholes	11	MH	5,000.00	55,000

Existing Utilities	5,200	lf	80.00	416,000
Dewatering	5,200	lf	20.00	104,000
Traffic Control	5,200	lf	20.00	104,000
	Year 1999 subtotal			2,100,000

Mobilization/Demobilization at 10% 1.10
Multiplier from ENRCCI 7137 (1999) to 7341 (2001) 1.03
Effective Multiplier 1.13

Year 1999 subtotal 2,100,000

SubTotal: $2,370,000

STA 84+00 to 183+00, Cost Calculations for Pipe: 30-in gravity section

Project year: 2001

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Construction Year: 2001
Length: 9900 ft
Conduit Type: Gravity Sewer
Depth of Cover: 10 ft
Trench Backfill Type: Imported
Manhole Spacing: Average (500 ft)
Existing Utilities: Complex
Dewatering: Minimal
Pavement Restoration: Half Width - Arterial (22 ft)
Traffic: Heavy
Land Acquisition: None
Required Easements: None
Trench Safety: Standard
Pipe Diameter: 30 in.

Geometry

Outer Diameter	3.08	ft
Trench Width	6.51	ft
Excavation Depth	14.1	ft
Complete Surface Rest. Width	8.51	ft

Unit Costs (Basis 1999)

Item	Quantity	Unit	Unit Cost	ItemCost
Excavation	33,608	CY	10.00	336,000
Backfill	21,477	CY	25.00	537,000
Complete Pavement Restoration	9,359	SY	50.00	468,000
Overlay Pavement Restoration	14,841	SY	20.00	297,000
Trench Safety	278,850	SF	0.50	139,000
Spoil Load and Haul	33,608	CY	10.00	336,000
Pipe Unit Material Cost	9,900	lf	50.00	495,000
Pipe Installation	9,900	lf	40.00	396,000
Place Pipe Zone Fill	9,393	CY	25.00	235,000
Manholes	20	MH	9,000.00	180,000

Existing Utilities	9,900	lf	80.00	792,000
Dewatering	9,900	lf	20.00	198,000
Traffic Control	9,900	lf	20.00	198,000
	Year 1999 subtotal			4,610,000

Mobilization/Demobilization at 10% 1.10
Multiplier from ENRCCI 7137 (1999) to 7341 (2001) 1.03
Effective Multiplier 1.13

Year 1999 subtotal 4,610,000

SubTotal: $5,210,000

East Lake Sammamish Parkway Route Total: $9,040,000

APPENDIX F: ENVIRONMENTAL REVIEW OF WASTEWATER ALTERNATIVES

KING COUNTY CONVEYANCE SYSTEM IMPROVEMENTS
SOUTH SAMMAMISH BASIN
ESA/HCP OVERLAY MEMORANDUM

Prepared by:

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PURPOSE

The purpose of this memorandum is to provide an overview of Endangered Species Act (ESA) regulations and the likely implications for Conveyance System Improvement (CSI) projects in the South Sammamish Basin. In addition, the memorandum describes the areas of known and probable endangered species habitat. Issues related to construction and operation of the conveyance system alignment alternatives will be outlined, as well as any other special considerations that should be taken into account for CSI planning. Alternatives referenced in this document refer to those alternatives described in the Task 240 memorandum for this basin.

ESA OVERVIEW

Existing data sources have been consulted for the locations of known endangered species habitat. These sources include:

- King County GIS databases (2001).
- A Catalog of Washington Streams and Salmon Utilization: Volume 1, Puget Sound Region (WDF Publication)(1975).
- State Salmon and Steelhead Stock Inventory (1994).
- Known Freshwater Distribution of Salmon and Trout for Water Resource Inventory Area 8, Greater Lake Washington Watershed. (King County online publication) (2000)
- Salmon and Steelhead Habitat Limiting Factors Report for the Cedar/Sammamish Basin, Water Resource Inventory Area 8 (September 2001)
- Washington State Department of Fish and Wildlife Priority Habitats Species Database (May 2000).
- Washington Department of Natural Resources Natural Heritage Program Information (2001).
- King County Current and Future Conditions & Source Identification Report, Issaquah Creek Basin (1991).
- King County Draft Basin & Nonpoint Action Plan, Issaquah Creek Basin (1992).

While some of these documents are dated, they represent the most current information available.

EXISTING HABITAT

Wildlife Habitat

The two proposed wastewater conveyance alternative packages in the South Sammamish Basin Planning Area (SSB) encompass a variety of habitats that support numerous species of wildlife. Additionally, the conveyance alternatives could occur in the vicinity of known federal and state endangered, threatened, and protected species. Wildlife species in the vicinity of any given alternative could include songbirds, red-tailed hawk, bald eagle, heron, deer, and coyote.

Within the SSB, breeding occurrences of bald eagles (*Haliaeetus leucocephalus*), great blue heron (*Ardea herodias*), and pileated woodpecker (*Dryocopus pileatus*) have been documented by the Washington Department of Fish and Wildlife (WDFW, 2002). An individual occurrence of tailed frog (*Ascaphus truei*) was also noted within the subbasin planning area. Bald eagles are listed as a threatened species under the ESA and tailed frog is listed as a species of concern by the federal government. Great blue heron and tailed frog are listed as state monitor species by WDFW and pileated woodpecker is a state candidate species. Bald eagles are also listed as threatened by the WDFW (WDFW, 2001). The presence of a listed species results in additional coordination and regulatory requirements including preparation of a biological assessment or evaluation, and depending upon potential impacts, possible consultation with the U.S. Fish and Wildlife Service and/or National Marine Fisheries Service. Compliance with this process can add several months and in some cases, a year or more to the schedule.

Fish Habitat

The SSB is located within Water Resource Inventory Area 8—Lake Washington/Sammamish River (WRIA 8) and includes five basins with numerous perennial creeks and small intermittent tributaries. The Sammamish River basin includes two small intermittent streams and the Sammamish River. The creeks in the East Lake Sammamish basin include the Panhandle subbasin creeks, George Davis Creek, Zaccuse Creek, Ebright Creek, Pine Lake/Kanim Creek, Monohon subbasin creeks, and Laughing Jacobs Creek. The Issaquah Creek basin includes Issaquah Creek, East Fork Issaquah Creek, and North Fork Issaquah Creek. Also included are the Tibbetts Creek basin, and Lewis Creek, Squibbs Creek, and other small tributaries in the West Lake Sammamish basin. All water flowing within the Planning Area discharges directly into Lake Sammamish or the Sammamish River.

Many of these watercourses are important spawning and rearing habitat for fish, including chinook salmon, which is listed as a threatened species under the Endangered Species Act (ESA). Appendix A (attached) lists the creeks and tributaries that could potentially be affected by the wastewater improvement construction activities along the conveyance route alternatives. The table in Appendix A includes information on the presence of fish species, alignment of watercourses relative to proposed alternatives, and the location of the creeks and tributaries. Figures 1 and 2 show areas where proposed wastewater pipeline improvements would potentially cross various streams.

Sammamish River Basin

The Sammamish River Basin drains a total of 150 square miles. The Sammamish River is approximately 13 miles long and relatively linear with a uniform channel configuration along much of its length. Land use adjacent to the river is a combination of urban, residential, and agricultural uses. There are two small streams and a wetland complex at the northeast end of Lake Sammamish and east of the Sammamish River as it flows out from the lake. No documented fish presence was found for these two small Sammamish River tributaries.

Construction of Alternative A from Alternative Package 1 includes an extension northward from Inglewood Hill Road that connects to the NE Lake Sammamish Interceptor. The extreme northern end of this extension passes to the east of the wetland and stream complex.

East Lake Sammamish Basin

<u>Panhandle Subbasin</u>. The Panhandle subbasin contains 13 small creeks that originate from seeps and springs on the west slope of the lake. Some are perennial streams and all flow at least six months of the year. These streams suffer from the typical impacts of urban development and alteration of the natural hydrologic regime. All of the creeks have problems with incision in steep stream reaches and sedimentation in the lower reaches. As a result, aquatic habitat is minimal. No fish have been observed in any of the 13 streams as the former railroad line, the East Lake Sammamish Parkway, and the steep slopes restrict access (Kerwin, 2001).

Construction for Alternative A from Alternative Package 1 would extend northward from Inglewood Hill Road crossing all 13 of these small tributary creeks.

<u>George Davis Creek</u>. George Davis Creek (08.0144) originates from wetlands on the Sammamish Plateau. George Davis Creek is a Class 2 stream that supports salmonids. The King County Code (KCC) (Title 21A.06.1240) utilizes a rating system to classify streams with a value from one to three. Class 1 streams are inventoried as "Shorelines of the State" under the King County Shoreline Master Program, class 2 streams are characterized as being smaller than class 1 streams but flow year-round or are used by salmonids, and class 3 streams are defined as intermittent during years of normal rainfall and are not used by salmonids.

Coho have been documented in George Davis Creek upstream of the East Lake Sammamish Parkway, although a culvert under a private residence has been identified as a fish passage barrier at river mile (RM) 0.2. Steelhead and cutthroat have also been documented in George Davis Creek and its tributary streams (08.0144A, 08.0144B, and 08.0144C) (King County, 2001).

Construction for Alternative A from Alternative Package 1 may cross George Davis Creek, depending on which of the three potential diversions is implemented and the construction alignment chosen (see Task 240 report, Alternative A description). The Inglewood Hill Road diversion is located north of George Davis Creek. The S-10 North diversion would cross George Davis Creek. The S-10 South diversion would be to the south of George Davis Creek.

<u>Zaccuse Creek</u>. Zaccuse Creek (08.0145A) originates in a series of wetlands at the west edge of the plateau and flows northwest to Lake Sammamish. It is a Class 2 stream with salmonids. Channel incision has been reported in the middle reaches of Zaccuse Creek and sedimentation has occurred in the downstream reaches, which degrades water quality.

Coho and cutthroat are documented in Zaccuse Creek. The presence of fish passage barriers and steep gradients limit the extent of fish access to the lower reaches of Zaccuse Creek (King County, 2001).

Construction for Alternative A from Alternative Package 1 may cross Zaccuse Creek, depending on which of the three potential diversions is implemented and the construction alignment chosen. The S-10 North diversion would cross Zaccuse Creek but the S-10 South diversion would be to the south.

<u>Ebright Creek</u>. Ebright Creek (08.0149) is a Class 2 salmon-bearing stream with two forks originating in a wetland complex on the Sammamish Plateau. There is a small unnamed creek (08.0155) just south of Ebright Creek that would likely be a class 3 stream. There is also a wetland near the mouth of Ebright Creek just to the east of the Lake Sammamish Parkway.

Coho, sockeye, kokanee, and steelhead have been documented in Ebright Creek up to a small dam at river mile (RM) 0.45. Coastal cutthroat trout are present in the stream above the dam (Kerwin, 2001). King County (1994) has documented erosion problems in the upper watershed and subsequent sedimentation problems in the lower watershed. Water quality monitoring also indicates that fecal coliform, total phosphorus, and turbidity concentrations have been high during storm events. There is no documented evidence of fish presence on the unnamed stream south of Ebright Creek.

Construction for Alternative A from Alternative Package 1 may come near Ebright Creek, depending on which of the three potential diversions is implemented and the construction alignment chosen. The Inglewood Hill Road diversion is located north of Ebright Creek. Construction northward from Inglewood Hill Road would not encounter Ebright Creek. The S-10 North and S-10 South diversions are south of Ebright Creek, so northward diversions from these locations would come near Ebright Creek.

Pine Lake/Kanim Creek Subbasin

The Pine Lake subbasin is approximately 1,175 acres and includes Pine Lake Creek (08.0152) and its major tributary Kanim Creek (08.0153). Both creeks originate in a wetland complex on top of the Sammamish Plateau that includes Pine Lake. Pine Lake Creek is a Class 2 perennial salmon-bearing creek. Department of Ecology listed the creek on the 1996 and 1998 303(d) lists for fecal coliform and recommends establishment of a total maximum daily load (TMDL) for the subbasin. Pine Lake Creek flows through a wetland on either side of the Lake Sammamish Parkway just before entering the lake.

Coho, chinook, and kokanee are known to be present in Pine Lake Creek (Kerwin, 2001) (King County, 2000) and sockeye presence is likely but it has not been documented (WDF, 1975). Coho use of Kanim Creek is also documented (Kerwin, 2001). Steelhead and cutthroat presence is documented for both Pine Lake and Kanim Creeks. Bed and bank erosion were identified as a problem in Pine Lake Creek by King County (1994). There are artificial barriers to fish passage on both creeks at approximately RM 0.5 on Pine Lake Creek and approximately RM 0.8 on Kanim Creek.

Alternative A from Alternative Package 1 will cross Pine Lake Creek below its confluence with Kanim Creek if the diversion begins at pump station S-10 South. S-10 North and Inglewood Hill Road are located north of Pine Lake Creek.

Monohon Subbasin

Numerous small tributary streams drain to Lake Sammamish in this subbasin including Many Springs Creek (08.0164A) and South Monohon Creek (08.0164B). These streams are short in length and steep in gradient and in combination with the presence of impassable culverts these streams together are limited to approximately 2,000 feet of fish accessible stream length. King County (1994) noted that Many Springs Creek has seen "catastrophic" stream channel incision.

Coho have been documented in Many Springs Creek and an unnamed creek (08.0163). Cutthroat and steelhead have also been documented for creek 08.0163 while only cutthroat were documented for Many Springs Creek.

Alternative C, Peak Flow Storage Sites, which is included in both of the CSI alternative packages, consists of multiple options for constructed storage facility sizing and siting. The northern part of the area designated in Alternative C for potential storage locations includes the fish bearing reaches of Many Springs Creek, South Monohon Creek, and the unnamed creek 08.0163.

Laughing Jacobs Creek

The Laughing Jacobs Creek Subbasin is approximately 3,600 acres and includes Laughing Jacobs Creek (08.0166). The *Salmon and Steelhead Habitat Limiting Factors Report* (Kerwin, 2001) indicates that chinook and coho in addition to sockeye, kokanee, steelhead, and cutthroat presence is documented for the lower reach of this creek. There is a natural fish passage barrier on Laughing Jacobs Creek at approximately RM 0.5 (Kerwin, 2001).

King County has rated this creek as a Class 2 stream that supports salmonid populations. Ecology listed the creek on the 303(d) list in 1996 and 1998 for exceeding fecal coliform criteria. The creek has high phosphorus concentrations from agricultural land uses and sediment loads which originate from active landslides in the lower reaches of the creek (the upper portions are underlain by bedrock) (King County, 1990).

Alternative C, Peak Flow Storage Sites, which is included in both CSI alternative packages, indicates potential storage locations near the lower reach of Laughing Jacobs Creek.

Issaquah Creek Basin

The Issaquah Creek Basin encompasses approximately 61 square miles in the southern portion of the Lake Sammamish Basin. The basin's headwaters are located on the steep slopes of Cougar, Squak, Tiger and Taylor Mountains. Elevations range from more than 3,000 feet at the peak of Tiger Mountain to near sea level at the mouth of Issaquah Creek entering into Lake Sammamish. The basin includes Issaquah Creek (08.0178) and its tributaries, the North (08.0181) and East (08.0183) Forks of Issaquah Creek as well as Holder (Issaquah Creek continues as Holder Creek), Carey (08.0218), Fifteenmile (08.0207), and McDonald (08.0212) Creeks.

The *Salmon and Steelhead Habitat Limiting Factors Report* (John Kerwin, Washington Conservation Commission, 2001) indicates that the upper Issaquah Creek Basin streams, Carey and Holder Creeks, provide particularly excellent habitats for salmonids. The high quality habitat and abundant populations of salmon distinguish the Issaquah Creek Basin as one of the three most significant basins in urbanizing King County.

North Fork Issaquah Creek Subbasin

The North Fork subbasin covers approximately 2,855 acres. Flow in this subbasin originates on the Sammamish Plateau at Yellow Lake, and enters the main fork of Issaquah Creek just upstream of Lake Sammamish. The North Fork of Issaquah Creek is low gradient in the upper and lower reaches but flows through a steep ravine near the middle of the watershed. A nine meter waterfall at the head of the steep ravine (RM 1.6) prevents anadromous fish migration to the upper watershed.

The *Salmon and Steelhead Habitat Limiting Factors Report* (Kerwin, 2001) indicates that chinook and coho, in addition to sockeye, steelhead, and cutthroat presence is documented for the lower reach of this tributary.

Alternative C, Peak Flow Storage Sites, which is included in both CSI alternative packages, indicates potential storage locations near the lower reach of North Fork Issaquah Creek. Alternative I2, Issaquah Highlands Diversion, which is also included in both CSI alternative packages, would cross the lower reach of North Fork Issaquah Creek and parallel the North Fork for approximately 5,000 linear feet. The alignment of Alternative I2 is within existing street rights-of-way, adjacent to other utilities.

Lower Issaquah Creek (mainstem) Subbasin

The Lower Issaquah Creek mainstem flows through the narrow valley at the head of Lake Sammamish. From the forks of the upper basin (Carey and Holder Creeks) to the mouth at Lake Sammamish, Lower Issaquah Creek is 11.4 miles long and has four major tributaries and 17 minor tributaries. Above (south of) SE 56th Street (RM 1.2) the creek varies in width between 20 and 40 feet and the riparian corridor width is less than 100 feet, but the channel has an excellent pool and riffle character.

Because of the excellent character of the channel above 56th Street chinook, coho, and sockeye have been observed spawning throughout the reach (King County, 1991). All of the major tributaries and most of the minor tributaries of Lower Issaquah Creek provide some habitat for salmonids as well. The *Salmon and Steelhead Habitat Limiting Factors Report* (Kerwin, 2001) indicates that kokanee, steelhead, and cutthroat presence is also documented for Lower Issaquah Creek.

Alternative C, Peak Flow Storage Sites, which is included in both CSI alternative packages, indicates potential storage locations near the lower reach of Issaquah Creek from the confluence of the East Fork down to SE 56th Street. Alternative I2, Issaquah Highlands Diversion which is also included in both CSI Alternative Packages, would be aligned in close proximity and parallel to Issaquah Creek between SE 56th Street and the confluence with the North Fork.

Tibbetts Creek Basin

The Tibbetts Creek (08.0169) basin is approximately six square miles in area and originates in a valley between Squak and Cougar Mountains. At its lower end below SE 56th Street the creek shares a floodplain with Issaquah Creek. The channel has been heavily impacted by development above and below (south and north of) SE 56th Street.

Historically, Tibbetts Creek was a highly productive stream for chinook, coho, steelhead, and cutthroat. Development has taken a great toll on the habitat of this creek but the *Salmon and Steelhead Habitat Limiting Factors Report* (Kerwin, 2001) indicates that coho, sockeye, kokanee, steelhead, and cutthroat presence is documented for the lower reach of this creek.

Alternative C, Peak Flow Storage Sites, which is included in both CSI alternative packages, indicates potential storage locations near the lower reach of Tibbetts Creek above SE 56th Street. The alignment of any tunnel storage project near downtown Issaquah should consider potential construction impacts to Tibbetts Creek. Alternative D1, Diversion to Eastside Interceptor, which is part of Alternative Package 2 could potentially cross Tibbetts Creek. Additionally, the pump station proposed as part of Alternative D1 is shown to be in the vicinity of Tibbetts Creek and adjacent wetlands.

West Lake Sammamish Basin

The West Lake Sammamish sub-area encompasses over 4,000 acres and 13 small streams. The streams relevant to this report include Squibbs (also called Vasa) Creek (08.0156), unnamed tributary 08.0160, and unnamed tributary 08.0161. Only the very lower reaches of these creeks are accessible to anadromous fish due to steep gradients, culvert blockages, and altered channel structure (Kerwin, 2001). These streams are generally short and steep.

The *Salmon and Steelhead Habitat Limiting Factors Report* (Kerwin, 2001) indicates that there is evidence of historical runs of coho and kokanee in Squibbs Creek and recent documentation for the presence of coho, sockeye, kokanee, and cutthroat. There is also evidence of resident cutthroat populations in unnamed tributaries 08.0160 and 08.0161.

Alternative D1, Diversion to Eastside Interceptor which is part of Alternative Package 2 will cross Squibbs Creek and unnamed tributaries 08.0160 and 08.0161.

Lewis Creek Subbasin

The 1,209-acre Lewis Creek Subbasin originates on the north slopes of Cougar Mountain. Lewis Creek (08.0162) flows northeasterly approximately 1.5 miles before it empties into the southern end of Lake Sammamish. The mainstem of Lewis Creek originates on a low gradient bench on the northeast side of Cougar Mountain. The creek then flows through a steep ravine down to Interstate 90 before entering another low gradient reach prior to flowing into Lake Sammamish.

The *Salmon and Steelhead Habitat Limiting Factors Report* (Kerwin, 2001) indicates that there is a large amount of documentation identifying chinook, coho, sockeye, kokanee, steelhead, and cutthroat presence in the lower reach of this creek below the I-90 culvert (RM 0.75). Upstream of I-90 only resident cutthroat have been observed.

Alternative D1, Diversion to Eastside Interceptor, which is part of Alternative Package 2 will cross Lewis Creek just below I-90.

Four unnamed and unnumbered Lake Sammamish tributaries are found between the Lewis Creek Subbasin and the Tibbetts Creek Basin. These tributaries are within the West Lake Sammamish Basin and three of the four are very short in length and steep in gradient. The fourth is steep in gradient but extends over 8,000 linear feet in length and divides into three headwater tributaries. These creeks are likely class 3 streams but could be accessible to resident and anadromous fish in the lower reaches. Little information of any kind exists for these streams.

Alternative D1, Diversion to Eastside Interceptor, which is part of Alternative Package 2 will cross at least two of these unnamed and unnumbered creeks below I-90.

LIMITING FACTORS

An understanding of limiting factors is an important first step in the environmental review of various CSI routes for several reasons. Most importantly, the significance of impacts is dependent upon the degree of limitation. For example, the impact of removing the last tree groves in a damaged riparian area would be more significant than removing a portion of the riparian vegetation in a densely vegetated area. It is important to understand limiting factors because this information is necessary when producing a Biological Assessment. An understanding of limiting factors is also needed to show how a given CSI route alternative will not further limit conditions below thresholds. Additionally, baseline information is such that more study is often necessary to determine actual field conditions in terms of limiting factors.

Most of the watersheds within the study area have been modified to some extent from natural conditions by development that has occurred over the past 150 years. Development impacts include land clearing for development, road construction, bank stabilization, and flood control projects. These types of changes have affected conditions within each stream although the degree of modification varies greatly by basin. Flood control and bank stabilization efforts have altered natural patterns of gravel migration and natural channel meandering in many of the basins. Agriculture, residential and commercial development, and landscaping are common throughout the entire CSI study area. These changes have resulted in stream conditions that are often limiting to fish. Because limiting factors vary dramatically by location and even by season, a more detailed, site specific evaluation of limiting factors should be included in the project-level environmental review of any proposed route alternative.

Ideally, reliable scientific information would exist for all listed populations that would allow the effects of an action to be quantified in terms of population impacts (NMFS, 1999). Given that the listing of chinook salmon is a relatively recent event (March 1999), little quantitative information is currently known regarding biological requirements for listed fish species in almost all basins. The limited information is generally only for major streams and little, if any, hard data is known regarding secondary streams and smaller tributaries.

The National Marine Fisheries Service (NMFS) guidance for conducting ESA reviews requires that in the absence of population-specific information, an assessment must define the biological requirements of a listed fish species in terms of properly functioning conditions (NMFS, 1996). Properly functioning condition (PFC) is the sustained presence of natural habitat-forming processes necessary for the long-term survival of the species through the full range of environmental variation. Indicators of PFC vary between different landscapes based on unique physiographic and geologic features. Since aquatic habitats are inherently dynamic, PFC is defined by the persistence of natural processes that maintain habitat productivity at a level sufficient to ensure long-term survival (NMFS, 1996).

The NMFS (1996) and the US Fish and Wildlife Service (USFWS) (1998) have developed guidelines to assist in conducting a limiting factors analysis related to the determination of project impacts on ESA listed salmonid fish based on the pathways and indicators listed in the following tables and narrative:

Table 1. Matrix of Pathways and Indicators

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Water Quality:	Temperature	50-75°F[1]	57-60° (spawning) 57-64° (migration & rearing)[2]	>60° (spawning) >64° (migration & rearing)[2]
	Sediment/Turbidity	<12% fines (<0.85 mm) in gravel3, turbidity low	12-17% (westside)[3] 12-20% (eastside)[2] turbidity moderate	>17% (westside)[3] >20% (eastside)[2] fines at surface or depth in spawning habitat[2], turbidity high
	Chemical Contamination/Nutrients	Low levels of chemical contamination from agricultural, industrial and other sources, no excess nutrients, no CWA 303(d) designated reaches[5]	Moderate levels of chemical contamination from agricultural, industrial and other sources, some excess nutrients, one CWA 303(d) designated reach[5]	high levels of chemical contamination from agricultural, industrial and other sources, high levels of excess nutrients, more than one CWA 303(d) designated reach[5]
Habitat Access:	Physical Barriers	Any man-made barriers present in watershed allow upstream and downstream fish passage at all flows	Any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at base/low flows	Any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a range of flows
Habit Elements:	Substrate	Dominant substrate is gravel or cobble (interstitial spaces clear), or embeddedness <20%[3]	Gravel and cobble is subdominant, or if dominant, embeddedness 20-30%[3]	Bedrock, sand, silt or small gravel dominant, or if gravel and cobble dominant embeddedness >30%[2]
	Large Woody Debris	>80 pieces/mile >24" diameter >50 ft. length[4]; >20 pieces/mile >12" diameter >35 ft. length[2]; and adequate sources of woody debris recruitment in riparian areas	Currently meets standards for properly functioning, but lacks potential sources from riparian areas of woody debris recruitment to maintain that standard	Does not meet standards for properly functioning and lacks potential large woody debris recruitment

Table 1. Matrix of Pathways and Indicators (cont.)

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Habit Elements (cont.):	Pool Frequency Channel width # pools/mile[6] 5 feet 184 10 feet 96 15 feet 70 20 feet 56 25 feet 47 50 feet 26 75 feet 23 100 feet 18	Meets pool frequency standards (left) and large woody debris recruitment standards for properly functioning habitat (above)	Meets pool frequency standards but large woody debris recruitment inadequate to maintain pools over time	Does not meet pool frequency standards
	Pool Quality	Pools >1 meter deep (holding pools) with good cover and cool water[3], minor reduction of pool volume by fine sediment	Few deeper pools (>1 meter) present or inadequate cover/temperature[3], moderate reduction of pool volume by fine sediment	No deep pools (>1 meter) and inadequate cover/temperature[3], major reduction of pool volume by fine sediment
	Off-channel Habitat	Backwaters with cover, and low energy off-channel areas (ponds, oxbows, etc.)[3]	Some backwaters and high energy side channels[3]	Few or no backwaters, no off-channel ponds[3]
	Refugia (important remnant habitat for sensitive aquatic species)	Habitat refugia exist and are adequately buffered (e.g., by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain viable populations or sub-populations[7]	Habitat refugia exist but are not adequately buffered (e.g., by intact riparian reserves); existing refugia are insufficient in size, number and connectivity to maintain viable populations or sub-populations[7]	Adequate habitat refugia do not exist[7]
Channel Condition & Dynamics:	Width/Depth Ratio	<10 [2,4]	10-12 (we are unaware of any criteria to reference)	>12 (we are unaware of any criteria to reference

Table 1. Matrix of Pathways and Indicators (cont.)

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Channel Condition & Dynamics: (cont.)	Streambank Condition	>90% stable; i.e., on average, less than 10% of banks are actively eroding[2]	80-90% stable	<80% stable
Channel Condition & Dynamics (cont.):	Floodplain Connectivity	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly
Flow/Hydrology:	Change in Peak/Base Flows	Watershed hydrograph indicates peak flow, base flow and how timing characteristics comparable to any undisturbed watershed of similar size, geology and geography	Some evidence of altered peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	Pronounced changes in peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography
	Increase in Drainage Network	Zero or minimum increases in drainage network density due to roads [8,9]	Moderate increases in drainage network density due to roads (e.g., ~5%)[8,9]	Significant increases in drainage network density due to roads (e.g., ~20-25%)[8,9]
Watershed Conditions:	Road Density & Location	<2 ml/ml [2,11], no valley bottom roads	2-3 ml/ml [2], some valley bottom roads	>3 ml/ml [2], many valley bottom roads
	Disturbance History	<15% ECA (entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs), ≥15% retention of LSOG in watershed [10]	<15% ECA (entire watershed) but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs), ≥15% retention of LSOG in watershed [10]	<15% ECA (entire watershed) and disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; does not meet NWFP standard for LSOG retention

Table 1. Matrix of Pathways and Indicators (cont.)

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Watershed Conditions (cont.):	Riparian Reserves	The riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatershed, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition >50%[12]	Moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (~70-80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better[12]	Riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition <25%[12]

1 Bjornn, T.C. and D.W. Reiser, 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.
2 Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995
3 Washington Timber/Fish Wildlife Cooperative Monitoring Evaluation and Research Committee, 1993. Watershed Analysis Manual (Version 2.0). Washington Department of Natural Resources.
4 Biological Opinion on Implementation of Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). National Marine Fisheries Service, Northwest Region, January 23, 1995.
5 A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.
6 USDA Forest Service. 1994. Section 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin.
7 Frissell, C.A., Liss, W.J., and David Bayles. 1993. An Integrated Biophysical Strategy for Ecological Restoration of Large Watersheds. Proceedings from the Symposium on changing roles in Water Resources Management and Policy, June 27-30, 1993 (American Water Resources Association), p. 449-456.
8 Wemple, B.C. 1994. Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon. M.S. Thesis, Geosciences Department, Oregon State University.
9 E.g., see Elk River Watershed Analysis Report, 1995. Siskiyou National Forest, Oregon.
10 Northwest forest Plan. 1994. Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern spotted Owl. USDA Forest Service and USDI Bureau of land Management.
11 USDA Forest Service. 1993. Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities.
12 Winward, A.H. 1989. Ecology Status of Vegetation as a base for Multiple Produce Management. Abstracts 42nd annual meeting, society for Range Management, Billings MT, Denver Co; Society for Range Management, p. 277.

Water Quality

Water quality indicators for Properly Functioning Conditions as described by NMFS (1996) and USFWS (1998) include temperature, sediment/turbidity, and chemical contamination/nutrients. Site-specific water quality information is typically unavailable for most of the smaller streams and almost all wetlands. Records are often incomplete, even for larger streams that have water quality information available. Also, most water quality information that has been collected in the past has been related to the needs of human health and may not necessarily reflect the requirements of ESA listed salmonids. Reliable, continuous information on temperatures, a particularly critical and often limiting parameter for salmonids, is commonly lacking in the available background information.

Habitat Access

Habitat access related to the upstream blockages to adult salmon is commonly one of the better documented indicators of Properly Functioning Conditions; however, analysis related to juvenile passage is less developed. While the importance of providing juvenile passage is becoming better understood, data on juvenile passage is not usually available to the same degree as for adult passage. Habitat access is of most concern in smaller streams or within the headwater areas of larger streams. Most of the streams within the study area have natural or human caused blockage issues, most commonly culverts. However, most of the stream reaches where CSI alternatives are being considered are below these barriers and are areas used by ESA listed salmonids.

Habitat Elements

Habitat elements include substrate, large wood, pool frequency, pool quality, off channel habitat, and refugia (NMFS, 1996; USFWS, 1998). The NMFS and USFWS define PFC for these indicators, respectively, as: gravel and cobble dominated substrate with less than 20 percent embeddedness; large wood (greater than 24 inches diameter and 50 feet long) at greater than 80 pieces per mile; approximately 70 pools per mile; a prevalence of high quality pools over 3 feet deep; a prevalence of backwaters and off-channel areas; and a prevalence of high quality refugia including adequate buffers and riparian reserves.

The loss of riparian vegetation, bank stabilization and armoring, and the loss of floodplain connectivity—particularly on Issaquah Creek—have limited the functionality of many of these habitat elements for most streams within the study area. However, the assessment of properly functioning habitat elements usually requires a site-specific evaluation at the project level since there is limited information for these elements for most of the smaller streams within the study. A lack of quantitative data limits the accuracy of determinations for substrate, large wood, pool quality, and pool frequency related to PFC for the smaller streams. However, it is often readily evident if a stream does not meet the thresholds of “properly functioning” for these elements. Projects that impact streams that are not properly functioning for particular habitat elements should be designed so that further decline is avoided.

Flow/Hydrology

Records of flow level and stream and wetland hydrology are commonly lacking for the smaller streams within the study area. Also, the information that is most commonly available either from historic gauge data or as a result of hydraulic modeling at the project level is usually of limited use when assessing limiting factors for fish. In the past, most flow and hydraulic data and evaluations have focused on peak flows during flood events. While these data are important to fish, information on seasonal baseflow conditions are of equal importance.

Lacking site specific data, often this indicator is evaluated in relation to the level of development that has occurred within a basin. Urbanization of stream basins generally results in changes in base flows and peak flows. Urbanization increases impervious surface area which decreases infiltration and may significantly alter stream baseflow (May et al., 1997). Pavement, roofs, and compacted surfaces increase runoff rates and even pervious areas such as lawns and landscaped beds have higher runoff rates than undisturbed native forest. NMFS (1996) and USFWS (1998) state that flow/hydrology is not properly functioning when there are pronounced changes in peak flows and base flows and there has been a significant increase in impervious surface coverage within a basin (most often attributed to roads). All of the streams within the study area are limited to some degree related to flows and hydrology.

Watershed Conditions

The NMFS (1996) and USFWS (1998) define “not properly functioning” watershed conditions as having many valley bottom roads, the disturbance of greater than 15 percent of the entire watershed, and fragmented riparian conditions. Although most project level environmental reviews do not include a specific evaluation of land use coverage within the entire basin, indicators related to this function are often evident based on the surrounding urban development. In all but a few areas, most watersheds in the study area have at least 15 percent of the basin that may be described as disturbed. The study area contains many valley bottom roads. These factors most likely add up to a “not properly functioning” watershed condition for most basins within the study area.

CONSTRUCTION CONSIDERATIONS

Most of the environmental considerations and permit requirements for conveyance system improvement projects arise from potential construction impacts to wetland and stream resources. Proposed routes that impact streams and wetlands often require additional permitting effort, particularly if the wetland or stream occurs in a basin with known or suspected use by ESA listed fish species.

STREAM IMPACTS

Stream crossing options commonly involve one of several methods: jacking and boring, microtunneling, directional drilling, or open-cut trench construction. The levels of impacts vary by construction method. A summary of each method related to environmental issues follows:

Table 2. Stream Crossing Construction Methods

Method	Positives	Negatives	Comments
Jack and Bore	• Limited or no impact to stream bed or banks. • Provides access to obstructions for removal via casing.	• Requires large pits adjacent to stream in riparian corridor. • May require dewatering channel if high water table.	• Issues with construction of pits in riparian area may be negligible if pits can be located in roadways, roadside areas, or disturbed areas.
Microtunneling	• Limited or no impact to stream bed or banks. • Can traverse longer distances between pits than jack and bore.	• Requires large pits. • May require dewatering channel if high water table. • Does not allow access to face. • May require alternate method if not successful.	• Low level of predictability for stream crossings where extensive geotechnical work is precluded by desire to limit impacts to stream.
Directional Drilling	• Does not require large jacking or receiving pits. • Does not require dewatering. • Can be used over long distances reducing need to impact riparian areas.	• Requires use of high pressure drilling fluid. • May require alternate method if not successful.	• Drilling fluid is typically non-toxic bentonite; however, can result in impacts to stream bed and increased turbidity if released to stream via overflow from receiving pits or fractures.
Open Cut	• Most predicable method related to impact assessment. • Typically quickest.	• Requires dewatering and direct disturbance to stream bed. • Short-term turbidity increases when water is re-introduced. • May result in channel dewatering if trench not properly plugged.	• Often the method of last resort.

Table 2 lists the six primary impact pathways that could directly affect streams and ESA listed fish species depending on the crossing method or combination of methods. Most impacts from pipeline crossings are temporary in nature and usually are limited to construction-related impacts; however, given the sensitivity of aquatic organisms to degradation, even short term impacts can be significant.

The following paragraphs provide more detail on the principal impact pathways associated with pipeline crossings.

Diversion and Stream Channel Dewatering

Diversion and dewatering most often results in adverse effects to listed fish. Chinook and other fish could be killed if not moved or otherwise precluded from the affected stream reaches.

The salvage or removal of fish and other aquatic life from the dewatered section of a stream is often a standard provision of the Hydraulic Project Approval (HPA) issued by the Washington Department of Fish and Wildlife (WDFW). Salvage can occur via several methods. Arguably, the most effective method involves using a direct-current backpack electrofisher to stun, and then remove, fish from the portion of stream to be dewatered. Other methods include the use of seine nets or kick nets to capture or herd fish from the construction area. The latter two methods are less effective than electrofishing in areas with riprap banks, abundant large wood, or in areas with cobble or boulder substrates. Regardless of the method employed, the removal of fish from a stream has the potential to harm or harass fish, thus resulting in a "may effect, likely to adversely effect" determination for the project during Section 7 consultation if listed fish are present (or thought to be present) within the drainage. However, it should be noted that it is likely that more fish would be killed during dewatering if removal were not attempted.

In addition to direct mortality or harassment resulting from dewatering, the construction of a diversion or bypass will serve to exclude fish and other aquatic life from the construction area. The bypass or diversion structure may also result in the blockage of upstream migration, downstream migration, or both, depending on the type of diversion. While most concern placed around blockages is in relation to adult upstream migration during spawning periods, any structure that impairs the free movement of juvenile fish is also likely to cause adverse effect if juvenile fish of a listed species are present in the stream and if the diversion or dewatering occurs for any length of time.

Dewatering may also result in the death of other aquatic organisms that may provide food for juvenile or rearing fish or wildlife. Therefore, it is often necessary to evaluate the potential effects the dewatering will have on the species' food base. Often densities of listed fish are below the carrying capacity of the stream, so food supply is not generally limiting; however, this may be a significant effect in streams where the listed species is relatively abundant.

Erosion and Sedimentation

Grading and excavation in proximity to the stream banks or riparian corridor could result in erosion from disturbed soils and increased sedimentation and turbidity in the adjacent stream unless properly mitigated. Overall, the potential for upland erosion and sedimentation to enter streams is commonly controlled by the implementation of various Temporary Sedimentation and Erosion Control (TESC) measures and other Best Management Practices (BMPs). While often effective in minimizing impacts from sedimentation and erosion, TESC measures and BMPs are not typically able to completely avoid off-site sediment transport under all conditions. These measures are difficult to successfully implement for site-based work and are particularly difficult to implement effectively for projects involving long construction corridors. Impacts related to sedimentation and erosion are a particular concern in urban and urbanizing stream basins where properly functioning conditions are already degraded.

Streams in urban or urbanizing basins may be sediment-limited, meaning that stream gravels are embedded with fine sediments as to limit the quantity and quality of available spawning habitat for listed salmonid species and other fish.

Even with effective TESC measures and BMPs in place, projects that require in-water work or the diversion of the stream will result in short-term, episodic increases in turbidity levels downstream from the work area. Work in the stream channel will re-suspend stream-bottom materials for a short period of time. Typically, increases in downstream turbidity are observed from several hundred feet to up to a half-mile below the work area. The degree of the increase in turbidity is largely dependent on substrate condition, the percent of fine materials present in the substrate, and the type of soils along the stream bank. Turbidity itself is not commonly lethal to fish except at extremely high levels (above those likely to be encountered for a stream crossing with proper BMPs in place); however, turbidity can alter the behavior of fish or cause them to avoid using habitats with higher than normal turbidity.

Discharges of Groundwater

Stream crossings or other construction in proximity to streams and wetlands often require dewatering of the trench or bore pits as a result of locally high groundwater levels. Dewatering is most often accomplished either by installing wells that are pumped to depress the local groundwater table or by pumping seepage directly from the pits or trench. In the past, the discharge of dewatering water has been a detail that is commonly left for the contractor to arrange; however, this practice can result in impacts to the adjacent stream or wetlands and should be included during the environmental review so that dewatering can be included as a permitted action.

There are typically two concerns with dewatering methods. The most common issue is that dewatering water is often highly turbid and may result in increases of turbidity below the discharge point. Even if the water is discharged to uplands and allowed to flow overland, it can still have a higher turbidity than background conditions. The potential effects of turbidity were discussed in the previous section. The second concern is that the discharge water could artificially effect the flow regime of the stream by increasing flows in the stream or by reducing flows if significant pumping is required to depress groundwater levels. These types of impacts are generally a more significant issue in urban or urbanized basins where natural stream flow conditions have been altered by the surrounding development.

Accidental Discharges

Almost all modern construction requires the use of heavy machinery. Both ESA listed fish and other aquatic life could be adversely impacted by the release of any potentially toxic materials (e.g., hydraulic fluid, gasoline, and oil) into the stream. Accidents such as spills are difficult to address in a site specific evaluation of project impacts because it is hard to anticipate where or when they may occur. For example, a spill of 50 gallons of fuel or hydraulic fluid onto a road would not likely have significant adverse impacts if it where cleaned up promptly. In comparison, a spill of only a few gallons directly into the water could have a significant adverse impact on fish. Typically, this potential impact is discussed in terms of avoidance through the implementation of BMPs or other construction management measures such as designated refueling areas and the development of other project-specific spill prevention and contingency plans.

Clearing and Grading

The most common indirect effects resulting from conveyance system improvements are usually related to clearing and grading of vegetation especially for conveyance systems that are parallel to a stream rather than a perpendicular crossing. Removing vegetation from the riparian area could result in a number of indirect effects to fish species. If clearing mature vegetation, it will not regenerate for several years, it could expose the stream to direct sun and increase water temperature, organic food inputs can be reduced, and large wood and other structural elements can be reduced. Soils disturbed by grading could provide a potential source of erosion and sedimentation if not properly stabilized following construction. If not properly revegetated and maintained after the work is complete, cleared areas are very susceptible to invasion by non-native and weedy species. This is especially true in urban and urbanizing areas and can result in long term impacts to the stream system rather than temporary disruption.

INTERRELATED AND INTERDEPENDENT ACTIONS

The ESA requires that federal agencies consider potential impacts to listed species resulting from actions that are interrelated to, or interdependent on, the primary project. Federal agencies often scrutinize sewer and road projects because of the potential for "urbanization" to effect the character of nearby waterways, resulting in adverse effects to fish and other aquatic organisms within nearby streams. It is possible that until the effects of urbanization are addressed on a regional basis, either through approved provision included via the Section 4(d) rulemaking process or through an approved Habitat Conservation Plan, NMFS and USFWS will continue to evaluate potential interrelated and interdependent actions on a project by project basis. This process may include obtaining the necessary ESA-related approvals for each potentially impacted water-body crossed by the proposed conveyance system alignment.

PERMIT CONSIDERATIONS

Provided below is a discussion of permitting issues associated with this conveyance project. Table 3 provides a summary of permit triggering activities.

Wetland Permit Issues

Conveyance system improvements that impact wetlands trigger the need for permit compliance at the local, state, and federal levels. Within unincorporated King County, projects that impact wetlands are subject to the requirements of Chapter 21A of King County Code. A wetland special study is required for all projects that impact wetlands or their buffers. King County regulations also require that disturbed wetlands and buffers be restored. Other local jurisdictions have similar requirements. At the state and federal levels, most pipeline projects with wetland impacts are permitted under the Section 404/401 Nationwide Permit System. The US Army Corps of Engineers (Corps) and the Washington State Department of Ecology (Ecology) are the federal and state agencies, respectively, with jurisdiction over most conveyance projects that impact wetlands. Depending on the circumstance, projects that impact wetlands may also be regulated by State Hydraulic Code and may require a Hydraulic Project Approval by the Washington State Department of Fish and Wildlife (WDFW).

Nationwide Permit 12 has been authorized to allow the construction of up to 500 linear feet of pipeline within wetlands. Projects with wetland impacts over 500 linear feet must be permitted following the Individual Permit process. There are many differences between the Nationwide and Individual permit pathways; however, the most significant is that the Corps may require the preparation of an alternatives analysis for Individual Permit project. An alternatives analysis may be required to show that the proposed project has fewer environmental impacts than other viable alternatives. Both the Nationwide and Individual permit process trigger Endangered Species Act Section 7 consultation and National Historic Preservation Act Section 106 consultation.

Stream Crossing Permit Issues

Commonly, conveyance system improvements that impact stream or riparian areas trigger the need for many of the same local, state, and federal permits and approvals as projects that impact wetlands. As with projects that affect wetlands, projects that impact streams within the County are subject to Chapter 21A of County Code and a stream special study may be required. A summary of the potential number of stream crossings associated with each alternative are summarized in the table below. These numbers likely represent worst-case scenarios, as some impacts may be avoided by minor route changes and engineering designs.

At the state and federal level, most pipeline projects with streams are permitted under the Section 404/401 Nationwide Permit System as discussed above for wetlands; however the HPA is almost always required for projects that directly impact streams. Nationwide Permit 12 has been authorized to allow the construction of up to 500 linear feet of pipeline within streams. Projects with over 500 linear feet of stream impacts must be permitted with an Individual Permit with the same requirements discussed above in the wetland section. The need for a COE permit triggers Endangered Species Act Section 7 consultation and National Historic Preservation Act Section 106 consultation for work in both wetlands or streams. A possible exception to the need for COE permit is for stream crossings that do not require in-water work, stream diversion or dewatering, or that do not otherwise impact wetland areas. In these instances, a COE nexus may be avoided and a Section 7 review would not be required unless the project included involvement from another federal entity in relation to other project elements.

Most permits require the restoration of the disturbed portions of stream bank and stream bed to pre-existing conditions. The most common effect of ESA planning and permitting on construction is generally related to the implementation of in-water work windows. In-water work windows commonly regulate not only construction that effects wetted areas of the stream, but any area below the ordinary high water mark of a drainage. For streams with wide floodplains or large associated riparian wetlands, this may include a larger area than just the region between the banks of the stream. Work windows vary depending on the basin and are commonly adjusted by the permitting agencies depending on the type of work and the fisheries resources within each stream. Typically fresh water work windows range from mid-June through mid-September but may be as short as July 1 through August 30 for streams with significant juvenile and adult use. Work windows may also extend to mid-October for smaller headwater streams that generally support populations of coho salmon and resident cutthroat trout. Work windows are commonly set as a condition of the HPA; however, NMFS and/or the Corps may require slightly different work windows to further reduce impacts to listed fish if applicable.

Table 3. Summary of Environmental Permit Triggers

Permit	Regulatory Authority	Triggering Activity
Section 404/401 Nationwide 12	Corps of Engineers	Utility line construction in wetlands up to 500 linear feet and up to 0.5 acre of impact. Triggers ESA and Section 106 Consultation.
Section 404/401 Individual Permit	Corps of Engineers	Utility line construction with wetland impacts exceeding limits for Nationwide 12. Triggers ESA and Section 106 Consultation.
Endangered Species Act (ESA) Consultation	National Marine Fisheries Service/US Fish and Wildlife Service	Utility line construction in or near habitat used by ESA listed species and projects receiving federal funding, license, or permit; or a federal project.
National Historic Preservation (Section 106)	Office of Archaeology and Historic Preservation (OAHP)	Utility line construction in or near habitat used by ESA listed species and projects receiving federal funding, license, or permit; or a federal project.
Hydraulic Project Approval	Washington Department of Fish and Wildlife	Work that uses, diverts, obstructs, or changes the natural flow or bed of state waters.
Sensitive Area Special Study	King County DDES	Impacts to wetlands in unincorporated King County.
King County Biological Review Panel (BRP)	King County DNR	Internal King County review panel reviews all Biological Assessments.

SUMMARY

Table 4 below presents the anticipated number of stream crossings associated with each segment of each alternative package. Based upon the conveyance system alternative alignment information review to date, it appears that Alternative Package 2 would result in a greater number of required environmental permits than Alternative Package 1. The selected alternative route would require a detailed field survey to determine the actual permitting and mitigation requirements associated with construction and operation of the conveyance system.

Table 4. Potential Number of Stream Crossing Associated with Each Pipeline Segment

Alternative	Number of Streams Within the Project Area
Alternative Package 1	**32**
Alternative A	**19**
Alternative I2	**3**
Alternative C	**10**
Alternative G	**Not Applicable**
Alternative Package 2	**22**
Alternative D1	**9**
Alternative I2	**3**
Alternative C	**10**
Alternative G	**Not Applicable**

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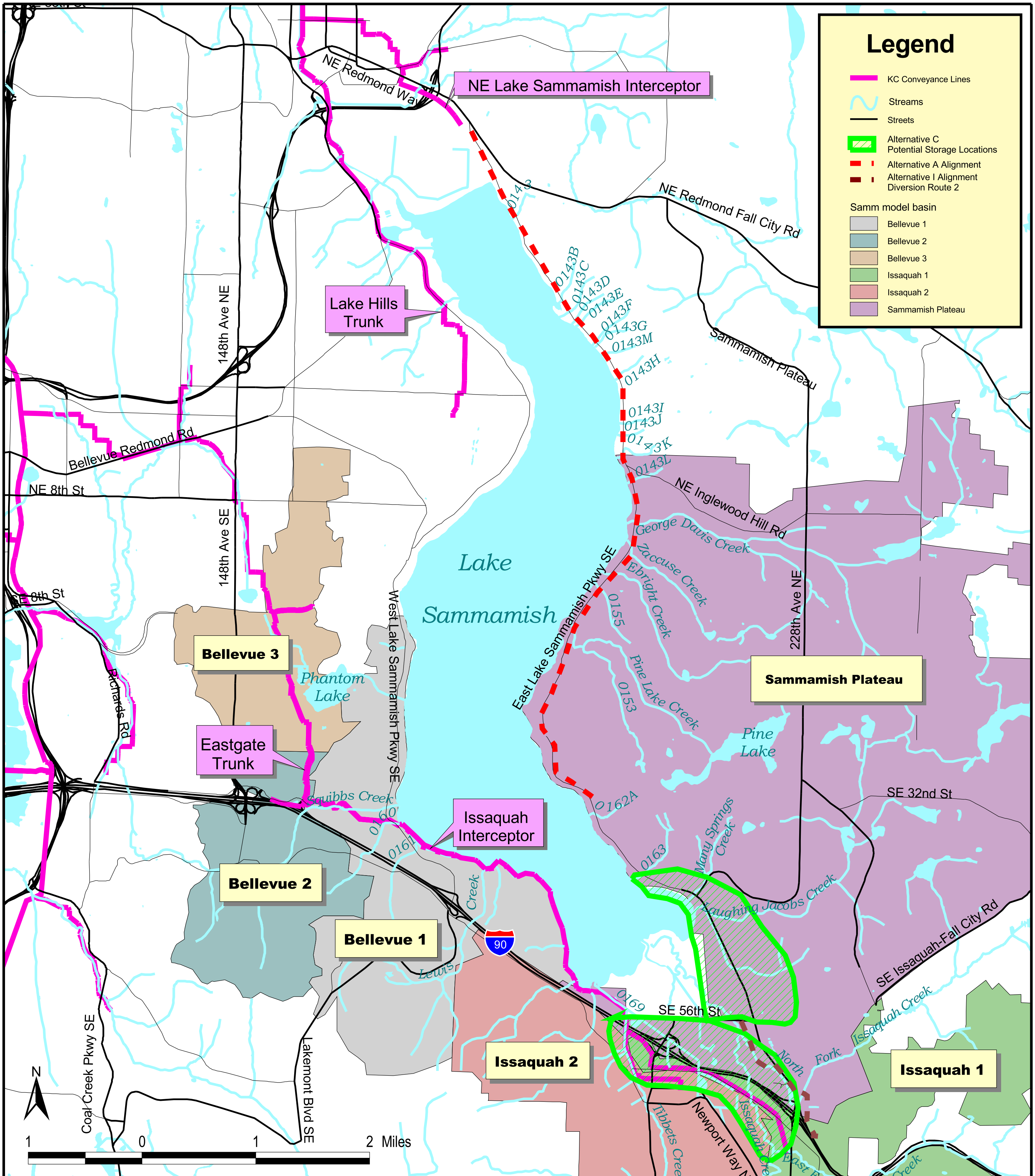

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FIGURE 1

STREAM LOCATIONS - ALTERNATIVE PACKAGE 1
TASK 240 - SOUTH SAMMAMISH BASIN CSI
KING COUNTY, WA

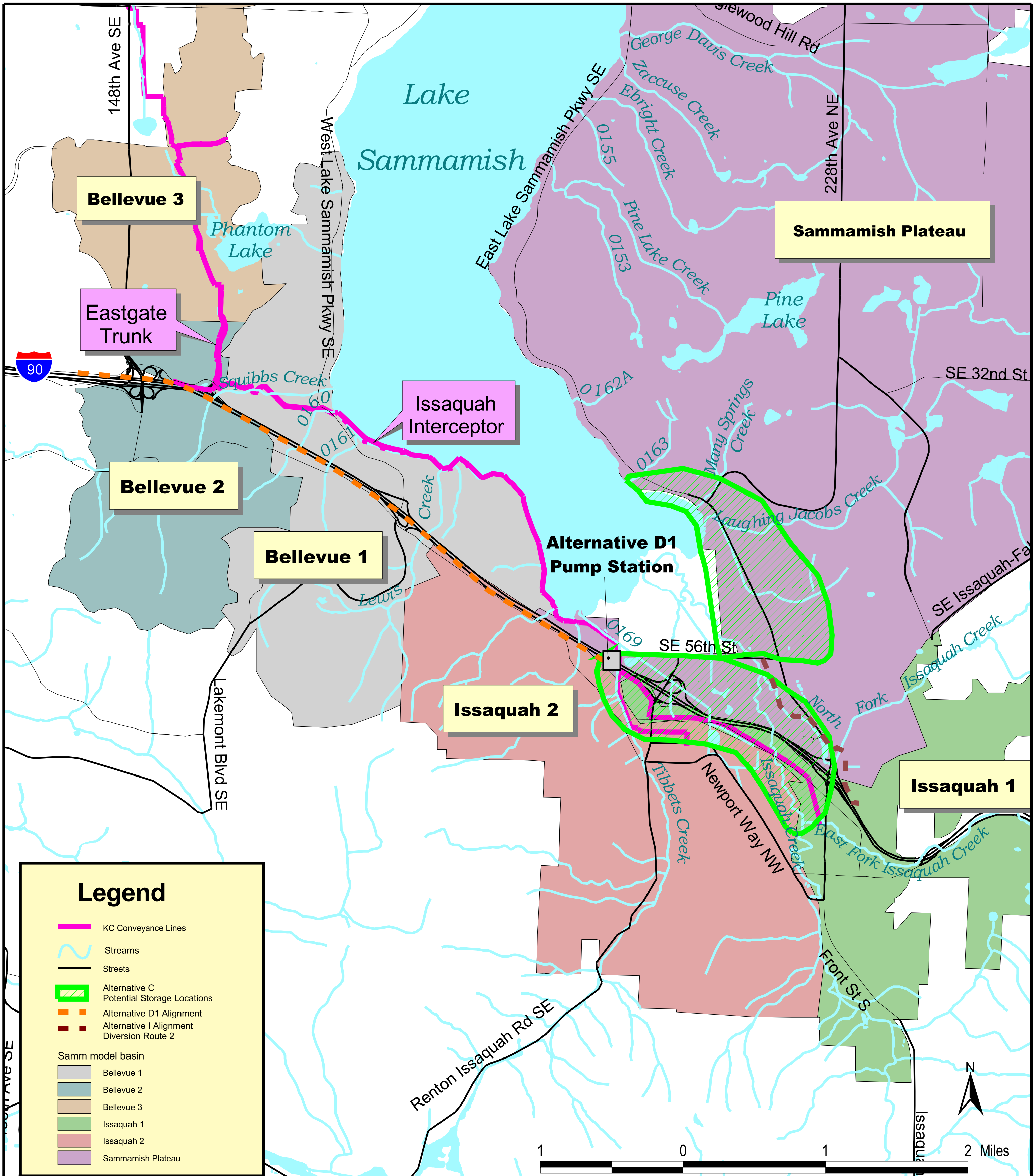

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FIGURE 2

STREAM LOCATIONS - ALTERNATIVE PACKAGE 2
TASK 240 - SOUTH SAMMAMISH BASIN CSI
KING COUNTY, WA

APPENDIX A

Appendix A.
South Sammaish Basin
Streams within the Basin and Documented Fish Use.

WRIA	Waterbody Number	Waterbody Name	Drainage Basin	Jurisdiction	Alternative Name	Type							Comments
							Coho	Chinook	Sockeye	Kokanee	Cutthroat	Steelhead	
8	08.0143A, 143B, 143C, 143D, 143E, 143F, 143G, 143H, 143I, 143J, 143K, 143L, & 143M	Unnamed	East Lake Sammamish	Sammamish	Alternative A Package 1	Crosses							No documented fish presence.
8	08.0144 and 08.0144A, 08.0144B, & 08.0144C	George Davis Creek	East Lake Sammamish	Sammamish	Alternative A Package 1	Crosses	WDFW 2002, King Co. 2001, WDFW 1994, Williams (likely)		Williams (likely)		King Co. 2001	King Co. 2001	Steelhead and cutthroat have been documented in George Davis Creek and its tributary streams (08.0144A, 08.0144B, and 08.0144C) (King County, 2001).
8	08.0145A, 08.0145B	Zaccuse Creek	East Lake Sammamish	Sammamish	Alternative A Package 1	Crosses	King Co. 2001, WDFW 1994				King Co. 2001		The presence of fish passage barriers and steep gradients limit the extent of fish access to the lower reaches of Zaccuse Creek (King County, 2001).
8	08.0149	Ebright Creek	East Lake Sammamish	Sammamish	Alternative A Package 1	Crosses	Kerwin, King Co. 2001, WDFW 2002, WDFW 1994		Kerwin, King Co. 2001	Kerwin, King Co. 2001	Kerwin, King Co. 2001,	King Co. 2001	Coho, sockeye, and kokanee salmon have been documented in Ebright Creek up to a small dam at river mile (RM) 0.45. Coastal cutthroat trout are present in the stream above the dam (Kerwin, 2001).
8	08.0155	Unnamed	East Lake Sammamish	Sammamish	Alternative A Package 1	Crosses							No documented fish presence.
8	08.0152	Pine Lake Creek	East Lake Sammamish	Sammamish	Alternative A Package 1	Crosses	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, Williams (likely)	Kerwin, King Co. 2001	Williams (likely)	Kerwin, King Co. 2001	Kerwin, WDFW 2002, King Co. 2001	Kerwin, King Co. 2001	Coho and kokanee are known to be present in Pine Lake Creek (Kerwin, 2001) and sockeye presence is likely but it has not been documented (WDF 1975). Steelhead and cutthroat presence is also documented for Pine Lake Creek. There are artificial barriers to fish passage at approximately RM 0.5 on Pine Lake Creek.
8	08.0153	Kanim Creek	East Lake Sammamish	Sammamish	Upstream of proposed conveyance improvements	---	Kerwin, King Co. 2001				Kerwin, King Co. 2001	Kerwin, King Co. 2001	Coho use of Kanim Creek is documented (Kerwin, 2001). Steelhead and cutthroat presence is also documented for Kanim Creek. There are artificial barriers to fish passage on Kanim Creek at approximately RM 0.8.
8	08.0162	Unnamed	East Lake Sammamish	Sammamish	Alternative A Package 1	Crosses	WDFW 1994, Williams (likely)						Coho presence is likely in this unnamed creek. This stream is short in length and steep in gradient and in combination with the presence of impassable culverts this stream has only a short reach accessible to fish.
8	08.0163	Unnamed	East Lake Sammamish	Sammamish	Alternative C	Storage	Kerwin, King Co. 2001, WDFW 1994				Kerwin, King Co. 2001	Kerwin, King Co. 2001	Coho have been documented in this unnamed creek as well as cutthroat and steelhead. This stream is short in length and steep in gradient and in combination with the presence of impassable culverts this stream has only a short reach accessible to fish.

Appendix A.
South Sammaish Basin
Streams within the Basin and Documented Fish Use.

WRIA	Waterbody Number	Waterbody Name	Drainage Basin	Jurisdiction	Alternative Name	Type	Coho	Chinook	Sockeye	Kokanee	Cutthroat	Steelhead	Comments
8	08.0164A	Many Springs Creek	East Lake Sammamish	Sammamish	Alternative C	Storage	Kerwin, King Co. 2001, WDFW 1994				Kerwin, King Co. 2001		Coho and cutthroat have been documented in this creek as well as and steelhead. This stream has only a short reach accessible to fish.
8	08.0164B	South Monohon Creek	East Lake Sammamish	Sammamish	Alternative C	Storage	Kerwin, WDFW 1994				Kerwin		Coho and cutthroat have been documented in this creek as well as and steelhead. This stream has only a short reach accessible to fish.
8	08.0166	Laughing Jacobs Creek	East Lake Sammamish	Sammamish	Alternative C	Storage	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, Williams	Kerwin, King Co. 2001	Kerwin, WDFW 2002, King Co. 2001, Williams	Kerwin, WDFW 2002, King Co. 2001	Kerwin, WDFW 2002, King Co. 2001	Kerwin, King Co. 2001	Chinook and coho in addition to sockeye, kokanee, steelhead, and cutthroat presence is documented for the lower reach of this creek. There is a natural fish passage barrier on Laughing Jacobs Creek at approximately RM 0.5 (Kerwin, 2001).
8	08.0178	Issaquah Creek (mainstem)	Issaquah Creek	Issaquah	Alternative C Alternative I2	Storage Parallel	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, KCSWM 1991, Williams	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, KCSWM 1991, Williams	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, KCSWM 1991, Williams	Kerwin, WDFW 2002, King Co. 2001, KCSWM 1991	Kerwin, WDFW 2002, King Co. 2001, KCSWM 1991	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, KCSWM 1991	Above SE 56th Street (RM 1.2) the creek varies in width between 20 and 40 feet and the riparian corridor width is less than 100 feet, but the channel has an excellent pool and riffle character. Because of the excellent character of the channel above 56th Street chinook, coho, and sockeye have been observed spawning throughout the reach (King County, 1991).
8	08.0181	North Fork Issaquah Creek	Issaquah Creek	Issaquah	Alternative C Alternative I2	Storage Parallel	Kerwin, WDFW 2002, King Co. 2001, KCSWM 1991, Williams	Kerwin, WDFW 2002, King Co. 2001	Kerwin, WDFW 2002, KCSWM 1991		Kerwin, WDFW 2002, King Co. 2001, KCSWM 1991	Kerwin	
8	08.0183	East Fork Issaquah Creek	Issaquah Creek	Issaquah	Alternative C	Storage	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, KCSWM 1991, Williams	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, KCSWM 1991, Williams	Kerwin, WDFW 2002, King Co. 2001, WDFW 1994, KCSWM 1991, Williams	Kerwin, WDFW 2002, King Co. 2001	Kerwin, WDFW 2002, King Co. 2001, KCSWM 1991	Kerwin, King Co. 2001	
8	08.0178	Holder Creek (Upper Issaquah Creek)	Issaquah Creek	King County	Upstream of proposed conveyance improvements	---	Kerwin, King Co. 2001, WDFW 1994, KCSWM 1991, Williams	Kerwin, Williams	Williams		Kerwin, KCSWM 1991	Kerwin, King Co. 2001, WDFW 1994, KCSWM 1991	The Salmon and Steelhead Habitat Limiting Factors Report (Kerwin 2001) indicates that the upper Issaquah Creek Basin streams, Carey and Holder Creeks, provide particularly excellent habitats for salmonids. The high quality habitat and abundant populations of salmon distinguish the Issaquah Creek Basin as one of the three most significant basins in urbanizing King County. Also resident Dolly Varden

Appendix A.
South Sammaish Basin
Streams within the Basin and Documented Fish Use.

WRIA	Waterbody Number	Waterbody Name	Drainage Basin	Jurisdiction	Alternative Name	Type	Coho	Chinook	Sockeye	Kokanee	Cutthroat	Steelhead	Comments
8	08.0218	Carey Creek	Issaquah Creek	King County	Upstream of proposed conveyance improvements	---	Kerwin, King Co. 2001, WDFW 1994, KCSWM 1991	Kerwin, KCSWM 1991	Kerwin, KCSWM 1991		Kerwin, King Co. 2001, KCSWM 1991	Kerwin, King Co. 2001, WDFW 1994, KCSWM 1991	The Salmon and Steelhead Habitat Limiting Factors Report (Kerwin 2001) indicates that the upper Issaquah Creek Basin streams, Carey and Holder Creeks, provide particularly excellent habitats for salmonids. The high quality habitat and abundant populations of salmon distinguish the Issaquah Creek Basin as one of the three most significant basins in urbanizing King County. Also resident Dolly Varden
8	08.0207	Fifteen Mile Creek	Issaquah Creek	King County	Upstream of proposed conveyance improvements	---	Kerwin, King Co. 2001, KCSWM 1991, Williams	Kerwin, KCSWM 1991, Williams	Williams (likely)		Kerwin, KCSWM 1991	Kerwin, King Co. 2001, KCSWM 1991	
8	08.0212	McDonald Creek	Issaquah Creek	King County	Upstream of proposed conveyance improvements	---	Kerwin, King Co. 2001, KCSWM 1991, Williams				Kerwin, King Co. 2001, KCSWM 1991	Kerwin, King Co. 2001	
8	08.0169	Tibbetts Creek	Tibbetts Creek	Issaquah	Alternative D1 Package 2 Alternative C	Crosses Storage	Kerwin, WDFW 2002, King Co. 2001, KCSWM 1991, Williams	Williams (likely)	Kerwin, King Co. 2001, KCSWM 1991, Williams	Kerwin, King Co. 2001	Kerwin, WDFW 2002, King Co. 2001, KCSWM 1991	Kerwin, WDFW 2002, King Co. 2001	Historically, Tibbetts Creek was a highly productive stream for chinook, coho, steelhead, and cutthroat. Development has taken a great toll on the habitat of this creek but coho, sockeye, kokanee, steelhead, and cutthroat presence is documented for the lower reach of this creek (Kerwin 2001).
8	no number found	Unnamed	West Lake Sammamish	Bellevue	Alternative D1 Package 2	Crosses					Kerwin		Resident cutthroat in lower reaches only due to steep gradients and blockages.
8	08.0162	Lewis Creek	West Lake Sammamish	Bellevue	Alternative D1 Package 2	Crosses	Kerwin, WDFW 2002, King Co. 2001, Williams (likely)	Kerwin, King Co. 2001	Kerwin, King Co. 2001	Kerwin, King Co. 2001	Kerwin, WDFW 2002, King Co. 2001	Kerwin, King Co. 2001	There is a large amount of documentation identifying chinook, coho, sockeye, kokanee, steelhead, and cutthroat presence in the lower reach of this creek below the I-90 culvert (RM 0.75). Upstream of I-90 only resident cutthroat have been observed (Kerwin 2001).
8	08.0161	Unnamed Creek	West Lake Sammamish	Bellevue	Alternative D1 Package 2	Crosses					Kerwin		Resident cutthroat in lower reaches only due to steep gradients and blockages.
8	08.0160	Unnamed Creek	West Lake Sammamish	Bellevue	Alternative D1 Package 2	Crosses					Kerwin		Resident cutthroat in lower reaches only due to steep gradients and blockages.
8	08.0156	Squibbs Creek	West Lake Sammamish	Bellevue	Alternative D1 Package 2	Crosses	Kerwin, King Co. 2001, WDFW 2002, Williams		Kerwin, King Co. 2001, Williams (likely)	Kerwin, King Co. 2001	Kerwin, WDFW 2002, King Co. 2001	WDFW 2002	